THE CARBONIFEROUS INSECTS.

PART II.

PAGES 81—156; PLATES V—X.
Title-page and Index.

QE
729
B65
1921
pt.2
ENT

260185

QE
729
B65
1921
pt. 2
ENT

565

Palæontographical Society, ~~1920~~.

A MONOGRAPH

OF THE

FOSSIL INSECTS

OF THE

BRITISH COAL MEASURES.

BY

HERBERT BOLTON, M.Sc., F.R.S.E., F.G.S.,

DIRECTOR OF THE BRISTOL MUSEUM.

Smithsonian Institution,
260188
National Museum.

PART II.

PAGES 81—156; PLATES V—X;
TITLE-PAGE AND INDEX.

LONDON:
PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.
JULY, 1922.

PRINTED BY ADLARD AND SON AND WEST NEWMAN, LTD., LONDON AND DORKING.

THE

PALÆONTOGRAPHICAL SOCIETY.

INSTITUTED MDCCCXLVII.

VOLUME FOR 1920.

LONDON:

MDCCCCXXII.

MONOGRAPH OF THE FOSSIL INSECTS OF THE BRITISH COAL MEASURES.

ORDER OF BINDING AND DATES OF PUBLICATION.

PARTS AND PAGES	PLATES	ISSUED IN VOL. FOR YEAR	PUBLISHED
General Title and Index	—	1920	July, 1922
1—80	I—IV	1919	July, 1921
81—156	V—X	1920	July, 1922

A MONOGRAPH

OF THE

FOSSIL INSECTS

OF THE

BRITISH COAL MEASURES.

BY

HERBERT BOLTON, M.Sc., F.R.S.E., F.G.S.,
DIRECTOR OF THE BRISTOL MUSEUM.

LONDON:
PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.
1921—1922.

PRINTED BY ADLARD AND SON AND WEST NEWMAN, LTD., LONDON AND DORKING.

SYSTEMATIC INDEX.

PAGE

INTRODUCTION 1
HABITS AND MODE OF OCCURRENCE OF FOSSIL INSECTS ... 5
CONDITIONS OF LARVAL INSECT LIFE 7
FOOD OF COAL MEASURE INSECTS 10
CLASSIFICATION... 11
FAUNAL ASSOCIATION... ... 18
SYSTEMATIC DESCRIPTIONS... ... 24
Order PALÆODICTYOPTERA ... 24
Family DICTYONEURIDÆ 24
Dictyoneura 25
— higginsii 25
Family ORTHOCOSTIDÆ 27
Orthocosta 27
— splendens 27
Family PTERONIDIIDÆ 29
Pteronidia 30
— plicatula 30
Family HYPERMEGETHIDÆ 31
Hypermegethes 32
— northumbriæ ... 32
Family CRYPTOVENIIDÆ 34
Cryptovenia 35
— moyseyi 35
Family MECYNOPTERIDÆ 36
Mecynoptera 36
— tuberculata ... 37
INCERTÆ SEDIS 40
Palæomantis 40
— macroptera ... 40
Family LITHOMANTIDÆ 42
Lithomantis 42
— carbonarius 43
Lithosialis 45
— brongniarti 46
Pruvostia 48
— spectabilis 48
Family BREYERIIDÆ... 50
Breyeria 50
— woodwardiana 50

PAGE

Order PALÆODICTYOPTERA (*cont.*)
Family SPILAPTERIDÆ 53
Spilaptera 53
— sutcliffei ... 54
Family LAMPROPTILIDÆ ... 56
Boltoniella 56
— tenuitegminata ... 56
Family BRODIIDÆ 57
Brodia 58
— priscotincta ... 59
— — juvenis ... 63
— furcata 66
"Pteronepionites" 67
— johnsoni ... 68
— ambigua ... 68
— lepus ... 69
Family ÆNIGMATODIDÆ ... 70
Ænigmatodes 71
— (?) regularis ... 71
Pseudofouquea 72
— cambrensis ... 72
INCERTÆ SEDIS... 74
Archeoptilus 74
— ingens 74
Order MIXOTERMITOIDEA 76
Geroneura 76
— (?) ovata 77
Order PROTORTHOPTERA 78
Ædœophasma 78
— anglica 78
Family COSELIIDÆ 81
Coselia 81
— palmiformis 81
Family ŒDISCHIIDÆ 84
Genentomum 84
— (?) subacutum ... 84
Xeroptera 85
— obtusata 85
Scalæoptera 88
— recta 88
Order PROTOBLATTOIDEA 90
Ptenodera 90

PAGE

Order Protoblattoidea (*cont.*)
Ptenodera dubius 91
Incertæ Sedis 92
Plesioidischia sp. 92
Order Blattoidea 93
Family Archimylacridæ 96
Aphthoroblattina 96
— johnsoni ... 96
— eggintoni ... 100
Archimylacris 103
— hastata 103
— woodwardi .. 106
— incisa 107
— (Schizoblatta) obovata 109
— sp. 112
— sp. 113
Phyloblatta 113
— sulcata 113
— transversalis 115
(Archimylacridæ) kirkbyi 118
Blattoids Incertæ Sedis 119
Family Mylacridæ 120
Hemimylacris 121
— obtusa 122
— convexa 123

PAGE

Order Blattoidea (*cont.*)
Family Mylacridæ (*cont.*)
Phylomylacris 124
— mantidioides .. 125
Soomylacris 128
— deanensis 128
— stocki 130
— burri 131
Orthomylacris 133
— lanceolata 133
Larval Blattoids 134
(Blattoidea) peachi 134
Leptoblattina exilis 136
Order Protodonata 139
Family Meganeuridæ 139
Meganeura 140
Boltonites 140
— radstockensis 140
Incertæ Sedis 144
Tillyardia 144
— multiplicata 145
Addendum 146
Archimylacris 146
— pringlei 146
BIBLIOGRAPHY 148
INDEX 154

LIST OF TEXT-FIGURES.

FIG.		PAGE
1.	*Orthocosta splendens*	28
2.	*Pteronidia plicatula*	30
3.	*Hypermegethes northumbriæ*	32
4.	*Cryptovenia moyseyi*	36
5.	*Mecynoptera tuberculata*	37
6.	Ditto	37
7.	*Palæomantis macroptera*	41
8.	Ditto	41
9.	*Lithomantis carbonarius*	43
10.	*Lithosialis brongniarti*	47
11.	*Pravostia spectabilis*	48
12.	*Breyeria woodwardiana*	51
13.	Ditto	51
14.	*Spilaptera sutcliffei*	54
15.	*Brodia priscotincta*	59
16.	Ditto	62
17.	Ditto, *forma juvenis*	64
18.	Ditto	65
19.	*Brodia furcata*	66
20.	"*Pteronepionites*" *johnsoni*	68
21.	*Enigmatodes* (?) *regularis*	71
22.	*Pseudofouquea cambrensis*	73
23.	*Archæoptilus ingens*	75
24.	*Ædæophasma anglica*	79
25.	*Coselia palmiformis*	82
26.	*Xeroptera obtusata*	85
27.	*Scalæoptera recta*	88
28.	*Ptenodera dubius*	91
29.	*Plesioidtischia* sp.	92
30.	*Aphthoroblattina johnsoni*	97
31.	Ditto	97
32.	*Aphthoroblattina eggintoni*	101
33.	*Archimylacris hastata*	104
34.	*Archimylacris woodwardi*	106
35.	*Archimylacris* (*Schizoblatta*) *obovata*	110
36.	*Phyloblatta sulcata*	114
37.	*Phyloblatta transversalis*	116
38.	*Hemimylacris obtusa*	122
39.	*Phylomylacris mantidioides*	125
40.	*Soomylacris deanensis*	129
41.	*Soomylacris stocki*	131
42.	*Soomylacris burri*	132
43.	*Orthomylacris lanceolata*	134
44.	*Boltonites radstockensis*	141
45.	*Tillyardia multiplicata*	145

PREFACE.

This monograph owes its existence to the friendly encouragement of Dr. A. Smith Woodward, F.R.S., Keeper, and of Dr. F. A. Bather, F.R.S., Deputy-Keeper of the Geological Department of the British Museum (Natural History), and to these gentlemen I am indebted for the loan of the undescribed Coal Measure fossil insects in their charge, and for much helpful assistance in other ways.

Others to whom my thanks are due are the Director of the National Museum, Washington, U.S.A.: Dr. F. L. Kitchin, of the Museum of the Geological Survey; Mr. G. W. Lee, of the Scottish Geological Survey; Dr. J. A. Clubb, of the Derby and Mayer Museums, Liverpool; Dr. W. E. Hoyle, of the National Museum of Wales, Cardiff; Prof. W. S. Boulton, of the Birmingham University; Dr. W. M. Tattersall, of the Manchester Museum, Victoria University; Mr. L. Gill, M.Sc., of the Hancock Museum, Newcastle; Mr. H. Y. Simpson, of the Kilmarnock Museum; and Messrs. Eltringham, S. Priest, W. Egginton, and D. Davies.

To Mr. W. J. Tutcher I am deeply indebted for his ready assistance in photographing all the various specimens submitted for examination. His remarkable skill has been always at my service, and by means of it I have been able to determine many details of structure which otherwise would have remained obscure.

I am indebted to the Royal Society for several grants towards the cost of the work.

H. BOLTON.

Family Coseliidæ, nova.

A group of large-winged insects in which the principal veins are openly spaced; the radial sector joined by an outer branch of the median, and the median sending a strong inward commissure to the cubitus.

The family shows relationships with the Œdischiidæ, Omaliidæ, and Caenrgidæ.

Genus **COSELIA**, novum.

Generic Characters.—Costa and subcosta feeble, intercostal area very wide; radius straight; radial sector arising near middle of wing. Cubitus S-shaped, its branches occupying most of the inner margin of the wing. Interstitial nenration of transverse nervures uniting in some areas to form an open meshwork.

Coselia palmiformis, sp. nov. Plate V, fig. 3; Text-figure 25.

Type.—Basal half of a left wing in counterpart in an ironstone nodule; British Museum (Johnson Collection, no. I. 15893).

Horizon and Locality.—Middle Coal Measures (binds between the "Brooch" and "Thick" coals); Coseley, near Dudley, Staffs.

Specific Characters.—Subcosta united to radius basally, giving off numerous branches, united by irregular cross-nervures, to the outer margin. Radius strong, divergent from subcosta. Radial sector diverging from the radius. Median steadily divergent from radius and radial sector, and giving off an inner branch in the first third of the wing to the main stem of the cubitus. Beyond the middle of the wing, the median sending off several outer branches, the first uniting with the radial sector. Cubitus with its divisions extending over the greater portion of the inner margin of the wing. First anal vein strongly curved, the next thrice forked.

Description.—This species is represented by a little over the basal half of a left wing, 54 mm. long and 26 mm. wide, showing the under surface only. The outer or costal margin is convex and very thin. The costal area very wide at its base (6 mm.) and diminishing towards the wing-apex.

The subcosta is a feeble vein, apparently united basally to the radius, and passing ontwards in a straight line towards the distal end of the outer margin, or into the outer part of the wing-apex. It gives off numerous branches to the outer margin, the branches being disposed regularly, and inclining apically in their course. They are joined by a few irregular cross-nervures, most of which are at right-angles to the branches of the subcosta.

The radius arises with an inward curve near the point at which the subcosta is given off, diverging from it and following a straight line to the wing-apex.

The radial sector arises near the middle of the wing, and at a distance of 38 mm. from the wing-base. The angle which it makes with the radius is fairly large, and the enclosed area must have been very wide in the outer half of the wing.

The median arises close to the radius, and then bends inwards as it passes to the inner half of the wing-apex. Its divergence from the radius is more than double that of the radius from the subcosta. Portions of two outwardly directed branches are shown, the first joining the radial sector; only the base of the second is preserved; it follows a course parallel with the first branch. About 21 mm. from the base the median gives off a strong inward branch passing obliquely to the cubitus and fusing with it. The cubitus is S-shaped, being convex outwardly to the junction with the commissural vein from the median, and concave inwardly afterwards. Owing to this inward inflexion, that part

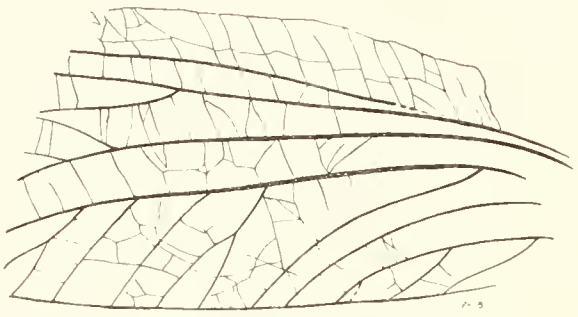


Fig. 25.—*Coselia palmiformis*, gen. et sp. nov.; diagram of basal portion of left wing, showing the general character of the venation, three-halves natural size.—Middle Coal Measures; Coseley, Staffordshire. Johnson Collection, Brit. Mus. (no. I. 15893).

of the cubital area lying beyond the junction with the median is extremely wide. The cubitus gives off four inwardly directed branches at wide intervals, the first branch having a wide forking in the first third of its length. The branches of the median must have occupied the greater part of the inner margin of the wing.

The cubitus gives off six inward branches, the first arising very low down, and the remaining five at regular intervals, the first being given off a little way beyond the junction with the commissural vein. The first and fourth of these branches fork into two widely separated twigs.

The first anal vein is simple, and has a broad convex outward sweep down to the inner margin; the second anal vein gives off three branches on its inner side. Other anal veins may have been present, but the wing-structure is missing at this point.

With the exception of the subcosta and radius, all the main veins are widely spaced, and no branches are given off, except the first median, in the basal third of the wing.

The interstitial neuration is well marked, and of unusual character. That

of the intercostal area has been already described; that between the subcosta and radius, between the radius and radial sector, and between the radial sector and the median, consists of a few irregular cross-nervures, one or two of which unite. In the median-cubital area the cross-nervures are joined up by longitudinal branches following a zig-zag course. A similar neuration is seen between the inner branches of the cubitus, while the anal area is crossed by irregular cross-nervures occasionally uniting, as in the fore-part of the wing.

Affinities.—The general characters agree most closely with those of the Cacurgidæ, a family of insects which Handlirsch has described from ironstone nodules found in and around Mazon Creek, Illinois, U.S.A. It comprises insects which possess well-marked characters, but which, as a whole, Handlirsch is unable to assign with certainty to the Protorthoptera, or to the Protoblattoidea (Handlirsch, 'Amer. Journ. Sci.' [4], vol. xxxi. 1911, p. 323).

The wing of *Cacurgus spilopterus*, Handlirsch, has the same wide costal area; the radial sector arises far out, and the median gives off a commissural vein to the cubitus. The central portions of the median and cubital areas are also very wide, and the anal veins have the same strong inward curve.

The interstitial neuration is much similar, but the formation of a meshwork has not proceeded so far in the British specimen as in *Cacurgus spilopterus*, where it is present between all the main veins, except the costal and subcostal. In the British specimen the meshwork is chiefly developed in the median and cubital areas. Areolæ are present in the wings of both species.

The differences between the wings of the two species are, however, important. In *Cacurgus spilopterus*, the first branch of the median does not unite with the radial sector, nor does it approach it very closely, whereas in the British wing, the first outer branch must have united with the radial sector. The median also branches again further out, the median in *C. spilopterus* having one outer branch only. *Lithosialis brongniarti* (Mantell) shows less affinity to the wing, but possesses the wide costal area, the same irregular and ramified interstitial neuration, but a more complex median and simpler cubitus. The commissural vein is also wanting.

One other form with which a comparison needs to be made is *Omalia macroptera*, Van Beneden and Coemans. This species was obtained from the Westphalian (Middle Upper Coal Measures) of Hainault, Belgium. In its wing the costal area is wide, and crossed by oblique branches from the subcosta; the median sends an outer branch to join the radial sector, but there is no union of the median and cubitus. The interstitial neuration is not mesh-like.

These wings are so similar that there seems no doubt they are closely related, but the relationship of the British specimen is closest with the genus *Cacurgus*.

Family Edischiidæ, Handlirsch.

1906. Handlirsch, Proc. U.S. National Museum, vol. xxix, p. 700, and Die Fossilen Insekten, p. 142.
1919. Handlirsch, Revision der Paläozoischen Insekten, p. 39.

Radial sector coalescing with the main stem of the median, and branching as if a part of the latter vein.

Handlirsch regards the family as closely related to the Sthenaropodidæ.

Genus **GENENTOMUM**, Scudder.

1885. *Genentomum*, Scudder, Mem. Bost. Soc. Nat. Hist., vol. iii, p. 329.
1893. *Edischia*, Brongniart, Faune Entom. Terr. Prim., p. 559.

Generic Characters.—Wings about three times as long as wide; principal veins and their branches well spaced, and united by a series of straight and well-defined nervures. Apex of wing obtuse.

Considerable doubt exists as to the true relationship of this genus, Scudder referring it to the Homothetidæ, Brauer considering it to have affinity with the Sialidæ, while Brongniart placed it with the Edischiidæ.

Genentomum (?) subacutum, Bolton. Plate V, fig. 4.

1911. *Genentomum subacutum*, Bolton, Quart. Journ. Geol. Soc., vol. lxvii, p. 334, pl. xxvii, figs. 18, 19.

Type.—Two small wing-fragments, 9 mm. in length, and 6 mm. in breadth; Bristol Museum (no. C. 972).

Horizon and Locality.—Lower Coal Measures (637 feet below the Bedminster Great Vein, and 137 feet above the Ashton Great Vein); South Liberty Colliery, Bristol.

Description.—One wing is partly superposed on the other, and the lower is also partially concealed by shale. The upper wing is represented by a portion of the distal inner portion, and by the wing-apex which is bluntly rounded. The outer margin is broken away, and the original size and shape of the wings cannot be determined.

The manner in which the wing-fragments are exposed on the shale renders systematic analysis of the neuration impossible. All the veins are narrow and sunk in the wing-membrane, while the interstitial neuration consists of transverse nervures arranged at right-angles, and dividing up the various areas into quadrangles. Where forking of the principal veins takes place, the resultant branches first diverge rapidly, and then pass outwards in parallel lines and at right-angles to the margin.

The lower wing-fragment shows a well-defined outer margin, evidently bounded by the costal vein. This margin is regularly and broadly convex, and shows signs of passing proximally into a straight or incurved line. The apex of the wing is narrow and bluntly rounded. The principal veins exposed appear to be portions of the radius, radial sector, and the distal branches of the median.

Affinities.—Fragmentary though these wings are, they nevertheless present features of unusual interest, as they are wholly unlike the blattoid wings found in the South Wales Coalfield, and are as yet the only insect-wings found in the Lower Coal Measures of the Bristol district.

The resemblance in venation and structure to locustid wings is remarkably close. There are the thin, sharply defined branch veins, and the division of the interspaces into rectangular areas by straight transverse nervures; and the texture is quite filmy, apart from the incised veins, as in Locustidæ.

Genus **XEROPTERA**, novum.

Generic Characters.—Wings more than three times as long as wide. Outer margin feebly convex. Subcosta ending far out. Radius reaching almost or to the wing-apex. Radial sector united by commissure to median. Median large, forming two main, equal-sized branches. Cubitus simple. Interstitial neuration of numerous straight cross-nervures.

Xeroptera obtusata, sp. nov. Plate V, fig. 5; Text-figure 26.

Type.—A right fore-wing in counterpart in nodule; British Museum (Johnson Collection, no. I. 1558).

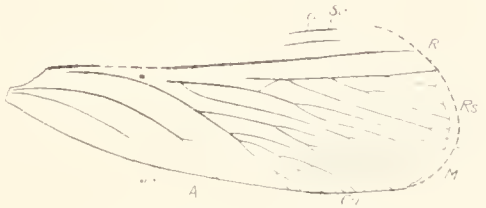


Fig. 26.—*Xeroptera obtusata*, gen. et sp. nov.: diagram of venation of wing, three-halves natural size.—Middle Coal Measures; Coseley, Staffordshire. Johnson Collection, Brit. Mus. (no. I. 1558). Lettering as in Text-figure 16, p. 62.

Horizon and Locality.—Middle Coal Measures (binds between the "Brooch" and "Thick" coals); Coseley, near Dudley, Staffs.

Description.—The wing is not complete, the whole of the outer margin being missing, or hidden by the matrix; the apex is raggedly torn, and much of the

inner margin is missing. So far as preserved it is 41 mm. long, and 16 mm. in greatest breadth.

The fore-wing lies on a hind-wing which is partly traceable, and both have been crumpled together, some of the veins of the hind-wing showing through the fore-wing. This renders the unravelling of the venation difficult, while the fragmentary condition of the stems of the main veins in the basal part of the wing hinders the definite determination of their course, and their relation to one another.

A small portion of the distally outer or costal margin has been uncovered sufficient to show that it was slightly convex. Close to the margin is a trace of the subcostal vein, proving that it continued well towards the wing-apex, if it did not reach the latter.

The outer part of the wing has been torn away along the area separating the subcosta and radius, and the latter vein is seen to traverse the whole length of the wing, but whether it joined the outer margin distally or came out on the wing-apex is not discernible.

The basal half of the radius is confused with the basal portions of the median and cubitus veins, owing to the crumpling which the wing has undergone. The radial sector arises in the basal half of the wing and diverges from the radius, a wide area separating the two. Soon after its origin it receives a branch from the median, and immediately afterwards gives off the first of three inwardly directed branches, the middle one soon dividing into two equal twigs, while the first branch forks on the margin. These divisions of the radius and the radial sector occupy the whole of the outer part of the wing-apex. The first branch of the radial sector probably represents the union of two twigs of the radius and median, and the small marginal fork may also represent their separation.

The median vein is incomplete basally, and appears to be large and much divided. Apparently it separates early into two main branches, the first dividing into two almost equal twigs, which again fork, the outer branch of each fork going forwards as an oblique commissure and joining the vein next in front. This is a somewhat unusual feature. The course of the outer twig after its juncture with the stem of the radial sector we have already traced. The outer twig of the second branch of the median, after fusing with the inner twig of the first branch, is probably continued by the inner of the two later divisions formed by that twig. The third branch of the median passes obliquely inwards, giving off an outer twig which forks twice, and, beyond the middle of the wing, gives off outer and inner branches from one point, afterwards forking twice before it reaches the inner margin of the wing. The whole structure ends in fourteen divisions on the distal half of the inner margin, and occupies a considerable area of the whole wing. It is possible that this complex of branching veins represents the median and cubitus combined, but I do not think it likely. If such be the case, the first branch given

off from the main stem is the median with four ultimate divisions, plus a branch to the radial sector, all the rest forming a much-divided cubitus with outer branches.

If this interpretation is correct, the next veins in the series are anal. Unfortunately, these are far too broken and uncertain in character to supply any evidence on the point. The first vein has a bold sweep from the base of the wing well outwards towards the middle of the inner margin, and seems to divide into a wide fork before reaching it. The second vein is simple, and may also fork, but low down, although it is impossible to say whether or no the forked appearance is due to a fold of the crumpled wing. If the two veins present are anal, then the anal area is very large, and the divisions of the cubitus are directed so as to lie almost wholly in the distal half of the wing. This appears unlikely. The divisions of the cubitus are usually simple, or but once forked, and usually directed inwards, ending normally on the middle of the wing-margin. The vein is united to the undoubted median stem and has a similar mode of branching, while its position on the margin is in the distal half. I see no reason, therefore, to regard this vein as a cubitus. The next vein, with its bold semicircular sweep to the margin, has the character of a cubitus, and so I regard it.

The second more incomplete vein may also be a cubital vein or the first anal. The interstitial neuration consists of a numerous series of straight cross-nervures.

The wing is thin and membranous.

Affinities.—The salient features of this wing include the union of the median with the radial sector and of one branch of the median with another, the considerable branching of the median and its extension on to the inner margin, the reduced cubitus, a small anal area and the long spathulate shape of the wing.

These general characters belong in varying degrees to a group of families, among which may be instanced the Œdischiidæ, Sthenaropodidæ, Spanioderidæ, and Geraridæ. The genus *Becquerelia* has the same development of the median, and in *B. superba*, a fusion of an outer branch of the median with the radial sector; but the wing is widest across the anal region, and the cubitus has a correspondingly increased development.

With *Schuchertiella* and *Gerarus* the relationship is perhaps closer, as in these genera the median is large and much divided, and the cubitus correspondingly reduced. Material differences debar a reference of the specimen to any of these families. I would assign it a position close to Œdischiidæ, in which the outer margin is nearly straight, the wing-apex rounded, and the median and radial sector united. Dr. Tillyard has suggested to me that the wing be compared with his archetype wing of the Panorpoid complex. There certainly appears to be a relationship, but this wing is specialised beyond the archetype, and too fragmentary for definite conclusions to be drawn from it. It cannot be referred to Œdischiidæ, however, because in that genus the subcosta is longer, the cubitus shorter, and with fewer twigs. I have therefore formed for it the new genus *Xeroptera*.

Genus **SCALÆOPTERA**, novum.

Large wings, 60 mm. or more in length. Costa marginal and slightly curved. Subcosta widely separated from margin and giving off straight, oblique and widely-separated branches to the margin. Radius parallel with the subcosta, and giving off the radial sector in the basal half of the wing. Median with few divisions. Cubitus long, with few divisions. Wing feebly plicate. Interstitial neuration forming a fine, close reticulation.

Scalæoptera recta, sp. nov. Plate VI, fig. 1; Text-figure 27.

Type.—Basal half of left wing in counterpart, having a length of 29 mm., and a width of 14 mm.; British Museum (no. I. 13878).

Horizon and Locality.—Middle Coal Measures (binds between the "Brooch" and "Thick" coals); Coseley, near Dudley, Staffs.

Description.—The inner margin of the wing is lost or concealed in the matrix.

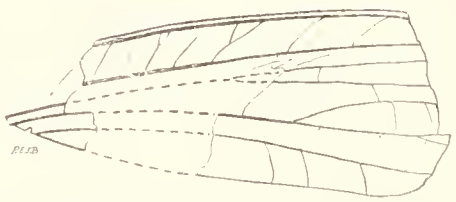


Fig. 27.—*Scalæoptera recta*, gen. et sp. nov.; diagram of the basal half of wing, twice natural size. Middle Coal Measures; Coseley, Staffordshire. Brit. Mus. (no. I. 13878).

while the anal area, and possibly a part of the cubital area, is missing. A portion of the nodule containing the distal half of the wing is lost. The total length of the wing could not have been less than 60 mm., and judging from its apparent relationships, may have been more.

The surface of the wing is slightly plicated, two low ridges bearing the radius and principal branch of the cubitus, while the subcosta and the median are deeply sunk. Its membranous portion is strongly coriaceous, with stout cross-nervures at wide intervals. The outer margin and the principal veins are feebly spinulose, as best seen on the radius and radial sector. The outer margin is feebly convex, the fairly straight course of the margin, and of all the principal veins, pointing to the wing being much longer than wide; a view also borne out, as we shall see later, by its possible relationships.

The subcosta is widely removed from the margin, parallel with it, and giving off a series of stout branches passing obliquely outwards to the margin. Of these divisions, one only is clearly forked.

Two portions of the radius are present, a short basal portion, and a second piece further out. The vein is separated from the subcosta by an interval less

than half that separating the subcosta and the margin. It lies also on a ridge which increases in strength distally. The radius and subcosta are parallel. The actual point of origin of the radial sector is not shown, but can be determined within narrow limits. It arises almost in the basal fourth of the wing, and so far as its course can be traced, diverges from the radius.

The median diverges along its whole course from the radius, and gives off on its outer side two branches, which remain undivided to the broken edge of the nodule. The first branch arises in line with the origin of the radial sector, and at an acute angle which soon enlarges, so that the interval separating it from the radial sector is less than half that separating them at their origin.

The cubitus divides into two nearly equal branches very low down in the base of the wing, the second branch sending off a short division against the broken edge of the nodule.

The stem of the median, and the two branches of the cubitus, have a parallel course, like the outer margin, subcosta and radius, the widening interval between the two groups of veins being occupied by the radial sector, and the two outer branches of the median. The direction of the subcosta, radius, radial sector, and first branch of the median, indicates that they traversed almost the whole length of the wing and ended on the wing-apex. The main stem of the median and the branches of the cubitus would reach the distal half of the inner margin. There are no traces of anal veins.

Affinities.—The extreme width of the intercostal area, the marked divergence of the costa, subcosta and radius from the median and cubitus, are features not readily recognisable among other known fossil insects. The few widely-spaced cross-nervures are not wholly peculiar to the specimen. Similarly, the spinulose principal veins are paralleled by those of *Brodia priscotincta* and *Archæoptilus ingens*. I have not seen so marked a coriaceous texture in any British fossil insect. The length of the wing-fragment before branching of the principal veins occurs, implies a long and relatively narrow wing. Such a wing-form is seen in the Palæodictyoptera and in the Protorthoptera. The wing differs from that of *Brodia priscotincta* in its much greater size, in the presence of a well-developed series of cross-nervures, and in the coriaceous surface of the wing-membrane. The direction of the radial sector and the divisions of the median vein are unlike those in *Brodia*, where these veins curve steadily from their points of origin inwards to the wing-margin.

Two groups of insects described by Handlirsch ('Amer. Journ. Sci.' [4], vol. xxxi, 1911), from the Pennsylvanian Series of the Carboniferous of Mazon Creek, Ill., under the family names of Spanioderidæ and Geraridæ, appear to resemble most nearly the wings we are considering. The wings in these families are long and narrow, and obtusely rounded at the apex, and the principal veins, especially in the Spanioderidæ, pass straight out for the whole, or the greater

part, of their length. Their costal area is also broader than the subcostal-radial area, and in both families the interstitial neuration consists of straight cross-nervures, except in the costal area, where they are oblique, as in this specimen.

These resemblances, however, are not sufficient to justify the inclusion of the new wing among the Geraridæ, because they are accompanied by equally or more important differences, such as the spinulose character of the principal veins, the great development of the intercostal area, the marked divergence of the stems of the radius and the median, the coriaceous wing-membrane and the much fewer cross-nervures. The wing, too, possesses quite a leathery texture, while the cross-nervures are broad and flat, forming conspicuous details of the surface.

With our present knowledge, it is only possible to infer that the wing is related to the Geraridæ and Spanioderidæ, that it is a Protorthopteroid, and that it still retains traces of its Palæodictyopteroid ancestry.

Order PROTOBLATTOIDEA, Handlirsch.

The Protoblattoids have a well-rounded head, a prothorax showing little or no expansion, and the wings intermediate in type between those of Palæodictyopteroids and Blattoids. The anal areas of the fore-wings or tegmina[1] are well marked out, and crossed by arcuate or oblique veins reaching the inner margin, while those of the hind-wings are enlarged and marked off from the rest of the wing by an anal fold. The body is more slender than in the majority of Blattoids.

The members of this order form a connecting link between the Palæodictyoptera and the Blattæformes. In many respects there is a close resemblance between the members of the order and those of the Protorthoptera, and the two may have arisen from nearly related stocks.

Genus **PTENODERA**, novum.

Generic Characters.—Subcosta reaching almost to the wing-apex. Radial sector twice furcate; median well divided, with its minor divisions crowded on the inner half of the wing-apex.

I have formed this genus to include a wing-fragment of unusual character in which the principal veins are long, and directed towards the wing-apex with few divisions, and the interstitial neuration consists of straight cross-nervures. The specimen shows that the branching of the principal veins is much similar to that of *Polyetes* among the Protoblattoidea, and to that of *Spanioderа schucherti*, Handl., among the Protorthoptera, in this respect supporting Pruvost, who has established

[1] The thickened rigid fore-wings of Blattoids are usually termed "tegmina."

a sub-order, Archiblattides, to receive many of the insects classed as Protorthoptera by Handlirsch.

The wing is apparently related also to *Scalaroptera recta*, Bolton, and as the latter shows no trace of the formation of an anal lobe, I class this genus with the Protorthoptera rather than with the Protoblattoidea. The Protoblattoidea probably arose from a Protorthopteroid stock.

Ptenodera dubius, sp. nov. Plate VI, fig. 2; Text-figure 28.

Type.—Distal half of a left wing, on the split surface of one half of an ironstone nodule; British Museum (Johnson Collection, no. I. 1559).

Horizon and Locality.—Middle Coal Measures (binds between the "Brooch" and "Thick" coals); Coseley, near Dudley, Staffs.

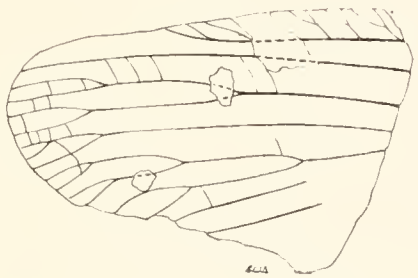


Fig. 28.—*Ptenodera dubius*, gen. et sp. nov.; diagram of apical portion of wing, twice natural size.—Middle Coal Measures; Coseley, Staffordshire. Johnson Collection, Brit. Mus. (no. I. 1559).

Description.—The ironstone nodule has been broken across, and that portion which contained the basal half of the wing has been lost. The distal portion of wing remaining is 27 mm. long, with a width of 16 mm. across the widest part. The width of the basal half of the wing was probably greater.

The distal half of the wing is thin and membranous, and a little wrinkled. The principal veins are well shown, but the interstitial nervures are only clearly visible when the nodule is immersed in water.

The costa is marginal and gradually curves into a well-rounded wing-apex. The subcosta is widely spaced from the costal margin basally, and gradually approaches it as it passes out towards the wing-apex, which it does not reach. It gives off to the wing-margin a series of oblique divisions, several of which fork.

The radius is simple, and passes straight to the wing-apex. Somewhat widely separated from the radius is the radial sector, which must therefore have been given off low down in the base of the wing. It divides into two equal branches, each of which is again equally divided, so that it ends on the middle of the wing-apex in four divisions.

The median vein is large and well branched. The nodule has been broken

across just beyond the point of division of the two main branches. The outer branch remains undivided until near the margin, where it forks twice, ending on the inner side of the wing-apex in three divisions. The inner branch forks into two equal twigs, the outer breaking up twice by equal forking into four divisions, while the inner twig forks once. Most of the divisions of the inner branch of the median end on the distal portion of the inner wing-margin.

Two incomplete branches of the cubitus are present, but the character of the vein cannot be determined. No traces of the anal veins are shown.

The principal veins and their main branches are well spaced, and follow the same general direction without being truly parallel. The interstitial neuration consists of fine straight cross-nervures.

Affinities.—The general character of the veins other than the subcosta is seen in several Palæodictyopteroid genera such as *Eubleptus*, but in none that I know are these characters accompanied by a similar type of subcosta. In the oblique, forked divisions of the latter, and the manner in which they are given off, as well as in the course of the subcosta itself, the wing most resembles that of the Protoblattoids, and to this group I would assign it.

INCERTÆ SEDIS.

Genus **PLESIOIDISCHIA**, Handlirsch.

1906. *Plesioidischia*, Handlirsch, Die Fossilen Insekten, p. 346.

Plesioidischia sp. Plate VI, fig. 3; Text-figure 29.

Type.—A fragment of a right wing, 40 mm. long and 10 mm. wide; Manchester Museum (no. L. 4905).

Horizon and Locality.—Middle Coal Measures (binds between "Brooch" and "Thick" coals); Tipton, Staffs.

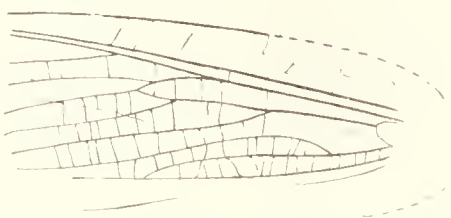


Fig. 29.—*Plesioidischia* sp.; diagram of venation of wing-fragment, three-halves natural size. - Middle Coal Measures: Tipton, Staffordshire. Manchester Museum (no. L. 4905).

Description.—The wing-fragment lies on the irregular surface of a small ironstone nodule, the outer costal margin and costal area on one half of the nodule, and the middle portion of the wing on the other. The base

and apex of the wing are missing, or still concealed in the matrix. Few definite factors are presented for determination, and the following description is the best we can give.

The outer margin of the wing is formed by the costa, and seems to be curved basally and straight distally. The costal area is widest at the base, and gradually narrows by the approach of the subcosta, which doubtless reached the outer margin far out. The costal area is crossed by a few stout straight branches of the subcosta. The subcosta passes straight from the base to the distal portion of the wing-margin.

The radius is close to and parallel with the subcosta. It gives off two inward diverging branches, the first uniting with the median, but giving off a secondary branch before it reaches the latter. The median gradually diverges from the radius. It gives off two well-marked inner branches, and then bends forwards to join the first branch of the radius. The point of union of the two branches gives origin to a backward twig parallel with the secondary branch of the radius, and with the two inner branches of the median.

The cubitus is represented by a long oblique vein going down to the inner margin. It gives off near its base an outer branch, which curves inwards parallel with the main stem, and reaches the wing-margin much beyond it. The wing appears to have broken along the level of a succeeding vein, but whether this was also a cubital or an anal vein it is impossible to determine.

The interstitial neuration consists of a series of stout strong cross-nervures. The texture of the wing seems to have been membranous.

Affinities.—The chief features of the wing are the strong parallelism of the veins, the numerous and strong cross-nervures, and the unusual mode of union of the radius and median. This assemblage of characters serves to place the specimen in the Protorthoptera, but it is not referable to any known genus, and is too incomplete to justify a new genus for its reception. The nearest approach appears to be *Progenentomum carbonis*, Handl., in which the subcosta reaches the middle of the wing, the radial sector unites with the median, and the interstitial neuration is of straight cross-nervures.

Order BLATTOIDEA.

The most numerous and varied insects found in the Coal Measures are the Blattoids, the recorded forms being classified in several families, embracing nearly 100 genera and 400 species. The early history of their study is dealt with by S. H. Scudder ('Mem. Bost. Soc. Nat. Hist.,' vol. iii, pt. 1, no. 3, 1879), and need not be repeated here.

Notwithstanding the abundance of specimens and forms known, they are insufficient for a satisfactory classification of the group, and do not provide the

stages in the life-history of any species. Handlirsch has recorded the occurrence of several egg-cases of Blattoids from the Carboniferous ('Proc. U.S. National Museum,' vol. xxix, p. 716, 1906). Larval forms have been described by Scudder, Handlirsch, Woodward, and especially by Sellards ('Amer. Journ. Sci.' [4], vol. xviii, p. 113, 1904), but in all cases the remains are too incomplete for satisfactory study.

The Coal Measure Blattoids show unmistakably that the race had a much earlier ancestry, as they depart widely from the Palæodictyopteroid type, and have attained a high degree of specialisation. The eggs were enclosed in capsules (Ootheca) much as in modern cockroaches, and the development was by a progressive metamorphosis, in which the rudimentary wings were formed at a relatively early stage, and increased in complexity of structure and size at successive ecdyses. It would also appear that the rudimentary wings were attached to the thorax by broad bases, and that the formation of an articular joint was not developed until the adult stage was reached. The elements of the thorax were as well developed in Coal Measure times as they are to-day, both in structure and function, while the legs, as seen in examples from Commentry (Allier), France, were long, spiny, or covered with stiff hairs, and well adapted for walking or running.

The wings display a remarkable diversity of neuration. The fore-wings are invariably modified by the formation of chitin into stout, horny structures, usually termed "tegmina," which served to protect the more delicate membranous hind-wings concealed beneath them. The costa is always marginal.

The hind-wings are not well known. When found, they are thin, membranous, larger than the tegmina, and folded beneath them. The enlargement of the wing has taken place over the inner half, the costal and radial areas being reduced, and the anal area not marked off from the rest of the wing by a furrow, as is seen in the fore-wings or tegmina. The wide variation in the neuration of the tegmina furnishes the only satisfactory data for classification. Assuming, as we must, that the Blattoids were derived from the Palæodictyoptera, the simplest form of Blattoid must be that in which the wing-neuration most nearly approximates to the latter type. This principle is the basis of Handlirsch's classification.

Modification of the wing-membrane for flight in the case of the hind-wings has brought about, or been accompanied by, a narrowing of the costal and radial areas, a reduction in the strength and extent of these veins, and an increased development of the median and cubital areas, coupled with an increased growth of the wing-membrane inwardly. The hind-wing is, therefore, a much more asymmetrical structure than the fore-wing or tegmen.

The abdomen is broad, somewhat flattened and well-segmented, but no positive evidence is known of an invagination of the terminal segments to carry the

egg-capsule. Cerci are present, and Sellards has identified long ovipositors, though this identification is not accepted by Handlirsch.

The habits of Carboniferous Blattoids can only be inferred from those of living forms. I have previously (p. 11) drawn attention to the occurrence of Blattoid wings among the leaves of *Cordaites* bearing numerous shells of the small annelid, *Spirorbis pusillus*, and suggested that the Blattoids frequented decaying vegetation to feed on the *Spirorbis* and similar organisms.

The tegmina of *Phylomylacris mantidioides* occur among masses of the spat ("*Ancylus rintii*") of *Anthracomya phillipsii* in coal shales of the Durham Coalfield. Most of the other Blattoid remains from the Coal Measures of this country have been found in sedimentary deposits in which Ostracods also occur. Apart from these facts, the general faunal associations of fossil insects to which I drew attention on pp. 18—24 are, I think, of great importance, as furnishing definite clues to habits. The same Arthropod-association still persists, and the lagunal and marshy phases of the Coal Measures would furnish a fitting and desirable environment for the whole series.

Classification.—The classification of the Carboniferous Blattoids is difficult, owing to lack of material. The known British forms are few in number, and have been found in several coalfields at horizons which cannot be correlated with each other or placed in a regular sequence.

Scudder's classification does not sufficiently take into account the relationship which undoubtedly exists between the Blattoids and the Palæodictyoptera, and it is based mainly on a knowledge of living forms. For this reason, probably, the Mylacridæ are placed as the first tribe in his group "Palæoblattariæ," in preference to the Archimylacridæ, in which a Palæodictyopteroid relationship is more clearly evident.

Handlirsch's classification gives greater attention to the ancestral type, and is also based on an examination of more numerous specimens than were accessible to Scudder. It is far from satisfactory, and will certainly be much modified when the collection of several thousand Blattoid remains from Commentry is fully worked out by Prof. Mennier, whose results are not yet published. Lameere's general classification ('Bull. Mus. Hist. Naturelle,' 1917, no. 1) is too uncertain to justify adoption.

Dr. P. Pruvost, who has given several years to a close study of the fossil Blattoids of the French and Belgian Coalfields, has modified Handlirsch's classification, and in his latest memoir (1920) he classifies the Blattoidea of Northern France as follows:

BLATTOIDEA.

Family Archimylacridæ.

Genera *Actinoblatta*, *Manoblatta*, *Archimylacris*, *Asemoblatta*, *Phyloblatta*, *Grypoblattina*, *Archæotiphe*, *Barroisiblatta*, and *Mesitoblatta*.

Family Mylacridæ.

Genera *Hemimylacris*, *Phylomylacris*, *Trilophomylacris*, *Soomylacris*, *Lithomylacris*, *Orthomylacris*, *Stenomylacris*.

Family Poroblattinidæ.

Genus *Premnoblatta*.

This classification seems to accord most nearly with recent discoveries, and is therefore adopted here.

Family Archimylacridæ, Handlirsch.

Body slender in primitive forms, broadened out in more specialised types. Cerci well developed and jointed. Legs slender and armed with spines. Antennæ slender. Pronotum subcircular. Subcosta distinct, with pectinate or equally spaced branches. Radius well branched, with or without radial sector. Median of one or two main branches. Radius, radial sector and median with outward branches only. Cubitus inwardly curved, and with inward branches. Anal furrow present. Anal area large, extending beyond the basal third of the wing. Interstitial neuration of straight nervures, or an irregular reticulation, or the two combined.

The greater number of Palæozoic Blattoids belong to this family, which is united to the Palæodictyoptera by transitional forms.

Genus **APHTHOROBLATTINA**, Handlirsch.

1906. *Aphthoroblattina*, Handlirsch, Proc. U.S. National Museum, vol. xxix. p. 719, and Die Fossilen Insekten, p. 183.

Generic Characters.—Tegmina two-and-a-half times as long as wide, with convex outer margin. Costal area narrow and strap-shaped. Subcosta extending over two-thirds the wing-length. Radius giving off radial sector near middle of wing, and sending a few simple branches to the apex. Radial sector forking into four or six branches. Median small, with few branches directed inwardly. Cubitus giving off 7—8 branches along its whole length, and extending well out towards the wing-apex. Anal area small.

Aphthoroblattina johnsoni (Woodward). Plate VI, figs. 4, 5; Text-figures 30, 31.

1887. *Etoblattina johnsoni*, Woodward, Geol. Mag. (3), vol. iv. p. 53, pl. ii, figs. 1 *a*, 1 *b*.
1906. *Aphthoroblattina*, Handlirsch, Die Fossilen Insekten, p. 183.

Type.—The pronotum and tegmina in an inverted position with traces of hind-wings on a small ironstone nodule, in counterpart: British Museum (Johnson Collection, no. I. 1067).

Horizon and Locality.—Middle Coal Measures (binds between the "Brooch" and "Thick" coals); Coseley, Staffs.

Specific Characters.—Tegmina slightly convex and expanded towards the apex, about two-and-a-quarter times as long as wide. Apex broadly rounded. Costal area occupying three-fourths of the outer margin of the wing. Subcostal vein weak. Radius almost straight and giving off the radial sector about the middle of its length. Radial sector doubly furcate. Median vein widely spaced across the middle of the wing. Cubital vein reaching the inner angle of the wing-apex, giving off outer and inner branches. Anal area large, and crossed by a few small anal veins. Hind-wings thin, larger than the tegmina, and with strong veins.

Description.—The elucidation of the neuration of the wings of the type specimen is difficult, owing to the venation of the hind-wings being impressed

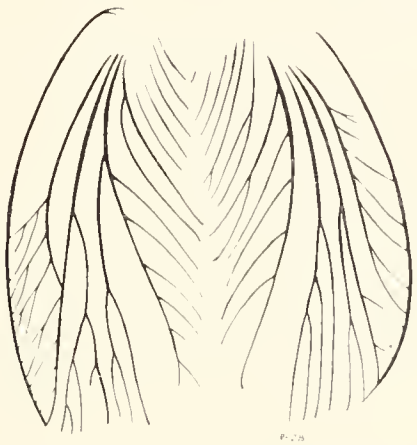


Fig. 30.

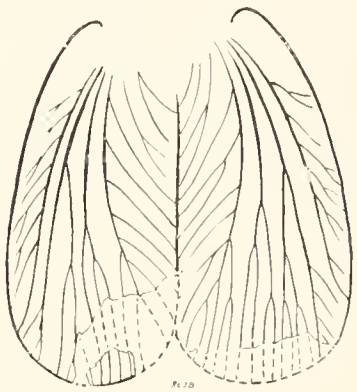


Fig. 31.

Fig. 30.—*Aphthoroblattina johnsoni* (Woodward); diagram of venation of the two fore-wings of the type-specimen, twice natural size.—Middle Coal Measures (binds between "Brooch" and "Thick" coals); Coseley, Staffordshire. Johnson Collection, Brit. Mus. (no. I. 1067).

Fig. 31.—*Aphthoroblattina johnsoni* (Woodward); diagram of venation of the fore-wings of a normal example of the type-series, twice natural size.—Same horizon and locality as Fig. 30. W. Egginton's Collection, "no. 2."

on that of the tegmina. The veins of the hind-wings are stronger than the distal portions of those veins of the tegmina which they overlie. It is probably owing to these factors that the original figures of the type are incorrect.

In both tegmina, as indicated by Dr. Woodward, the median and cubitus are shown as united, whereas this union takes place in the left wing only. Neither of the figures gives an adequate indication of the presence of the hind-wings. In the larger figure the radius and cubitus are represented by a single vein, which is also incorrect. Allusion has already been made to the wings lying on the smaller portion of the nodule in an inverted position. This is demonstrated by the pronotum, which dips under the mesonotum into the matrix, and by the deep impressions of the veins of the hind-wings crossing over, and not under, the veins of the tegmina. The veins of the tegmina are also in relief, instead of being sunken as they normally are on the dorsal surface.

The pronotum has a diameter of 13 mm., and 8 mm. of its length is exposed. The sides curve evenly backwards, and show no sign of flattening, so that its general shape is semicircular. The hinder border is hidden, and disposed at an angle to the surface-plane of the wings. The presence of a sunken, central, pyriform area on the inner surface of the pronotum probably marks the position occupied by the head of the insect. The downward inclination of the front margin of the pronotum, and the elevation of the hinder border, is a frequent feature in the Coal Measure Blattoids.

During life a small gap interposed between the pro- and mesonotum, and this became filled up by sediment on burial in sufficient quantity to cause the pronotum to be lifted from the body of the insect by that half of the nodule which carries the wing-impressions. This inclined position of the pronotum is so common that it appears to have been normal.

The mesonotal area is covered by the anal areas of the tegmina, and its character cannot be determined.

The venation of the right tegmen differs considerably from that of the left. The under surface of the latter is the more nearly perfect, and the venation is more distinct. The costal margins of the tegmina form two broad arcs, sharply bent inwards at the base, and distally merging into the wing-apex. The left subcosta is widely separated from the margin, giving off three oblique branches which fork, the first twice, before reaching the margin. Beyond these branches, the left costa curves inwards and unites with the main stem of the radius at the distal third of the wing. The right costa is more normal, and does not unite with the radius. It gives off six outward branches, of which only the first is forked.

The left radius, after a slight basal curve, passes straight out to the apex, giving off four forward branches, the first forked. This first forked branch appears to be the continuation of the subcosta. The radius of the right tegmen gives off two simple outer branches only.

There is a wide difference between the radial sectors of the two tegmina. That of the left divides in the middle of its length into two equal branches, which in turn fork, the outermost twig forking again, so that the radial sector ends on the margin in five divisions. The right radial sector forks once only beyond the middle of its length, and ends on the margin in only two divisions.

The median in each tegmen is a comparatively simple vein, that of the left being united with the cubitus in the basal fourth, and separating from it at an acute angle. Beyond the middle of the wing it gives off a single forked branch on its outer side. These divisions of the median, with the first branch of the radial sector, occupy the inner half of the apex. The median of the right tegmen is well separated from the cubitus along its whole length, and passes in a bold curve to the inner half of the apex, giving off four simple outer branches.

Apart from its union with the stem of the median, the cubitus of the left

tegmen agrees fairly well with its fellow. Both veins curve inwards, and reach the junction of the inner margin with the apex, and both give off 6—7 branches inwardly, the first branch in each case forking.

Which forward branches were given off on the outward side of the cubitus in the left tegmen cannot be made out, but faint furrows on the right tegmen seem to indicate that three simple outer veins were present.

The anal area is long and acutely ovate, extending over nearly a third of the inner margin. Six anal veins are present, the distal one with a strong fork.

The interstitial neuration consists of stout, straight nervures, not always well shown. The inner margin is nearly straight.

The veins of the hind-wings are very fragmentary. They are much thinner than those of the tegmina, and have left a much slighter impress. They appear to consist of a straight costa, separated by a very narrow area from an equally straight subcosta, below which can be made out a portion of the radius, radial sector, and median.

All the veins are widely spaced, and the breadth of the hind-wings must have been about double that of the tegmina.

The dissimilarity between the neuration of the left and right tegmina in the type-specimen suggests a wide varietal range among Coal Measure Blattoids, a feature which needs to be taken into account in the definition of species.

The presence of these abnormalities in the type-specimen somewhat militates against its value for reference, and I therefore add other details from a second example which I received from Mr. W. Egginton. The specific characters given above have been drawn up from this specimen, which lies in a small ironstone nodule, marked "No. 2." having a length of 43 mm. and a breadth of 38 mm. The Blattoid has a total length of 33·5 mm., and a maximum breadth across the tegmina of 24 mm. The inner margins of the tegmina overlap, evidently in their position of rest during life.

The pronotum, apparently in natural position, lies a little out of the horizontal, the front margin dipping downwards, and the hinder margin upwards and a little forwards, so that a slight gap occurs between it and the wings. This feature we have already alluded to, and in this case the pronotum has been carried away as usual, but the wings remain, so that the wing-impressions with the pronotum are on the upper surface of one half of the nodule, the other half carrying the pronotal impression and the wings.

The pronotum is 12 mm. wide and broadly rounded, only a little more than half being visible. It shows a central raised area, oval in outline, and defined from the margins by lateral grooves. The meso- and meta-notal segments show as a low, flat, elongated, heart-shaped region overlain by the anal areas of the tegmina.

Both tegmina are still attached high up on the sides of the body. So far as can be determined through the substance of the tegmina, the hind-wings are

attached nearer the middle line, and almost on the upper surface. All four wings are present, the tegmen of the right side being perfect, while that on the left has lost a portion of the inner part of the apex. The right tegmen is 25 mm. long, and 12 mm. wide at its broadest part.

The costal margin is broadly arcuate, and merges into a well-rounded apex. The subcosta is feeble, and gives off 7—10 very oblique branches, each breaking up into numerous twigs before reaching the margin. The intercostal area is wide and strap-shaped, and occupies the greater part of the outer margin.

The radius is well separated from the subcosta at its base, and diverges a little from it along its course. It gives off the radial sector before the middle of the wing is reached, and then passes forward undivided until near the end of the subcosta, where it gives off four or more short oblique branches forward.

The radial sector diverges strongly from the radius, and, like the latter, remains undivided for the greater part of its length. In the last third it gives off two, possibly three, outer twigs, which fork before reaching the margin. The interradial area at the point where the first branch arises is very wide.

The median arises close to the radius, but soon bends strongly towards the inner side of the apex. It gives off three outer parallel branches, the first of which forks.

The cubitus is a powerful and large vein, well apart from the median at its origin, and passing above the middle of the wing in its proximal third, beyond which it curves inwards to the end of the inner margin. It gives off six simple branches and ends in a feeble fork, while two strong branches arise on the outer side and pass to the apex.

The anal area is large, occupying one-third of the margin, and containing six anal veins, the first, second and third forking.

The inner margin is almost straight. The interstitial neuration consists of numerous raised cross-nervures, best seen in the anal and cubital areas. In the radial and median areas the cross-nervures unite laterally and occasionally fork.

Portions of the hind-wings are present, but only the distal branching of the radial sector, median and cubitus is shown beyond the broken end of the left tegmen. The course of the radius and median is traceable across the surface of the tegmen of each side.

The wing-membrane is so thin as to be scarcely discernible.

Aphthoroblattina eggintoni, sp. nov. Plate VI. fig. 6; Text-figure 32.

Type.—Pronotum, tegmina and portions of hind-wings lying on the surfaces of a split ironstone nodule; "No. 1" in the Collection of Mr. W. Egginton.

Horizon and Locality.—Middle Coal Measures (binds between the "Brooch" and "Thick" coals); Coseley, near Dudley, Staffs.

Specific Characters.—Costal margin convex. Cubitus long, strap-shaped, and extending almost the whole length of the outer margin. Radial sector with few simple branches. Median vein forking three times, and ending in middle and inner side of the wing-apex. Cubitus extending the whole length of the inner margin, with no evident outer branches, and feeble forking.

Description.—The specimen is contained in a small greyish-brown nodule, 48 mm. long and 35 mm. wide, and lies with the dorsal surface of the wings and the impression of the pronotum on one half of the nodule, and the wing-impressions and pronotum on the other half. The remains are in good condition, and show a small portion of the head, the pronotum and mesonotum, almost the whole of the left tegmen, and the basal two-thirds of the right tegmen, while a portion of the left hind-wing is disclosed over that area from which the fragment of the

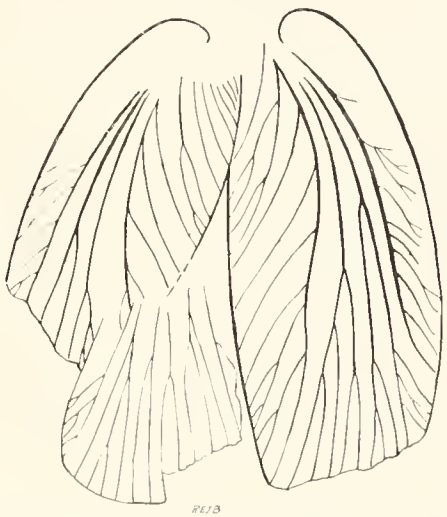


FIG. 32.—*Aphthoroblattina eggintoni*, sp. nov.; diagram of venation of fore-wings and portion of left hind-wing, twice natural size. Middle Coal Measures (binds between "Brooch" and "Thick" coals); Coseley, Staffordshire. W. Egginton's Collection, "no. 1."

tegmen is missing. That both hind-wings are present is indicated by their principal veins showing in feeble fashion through the tegmina.

The head is small, not more than 3 mm. of its length being visible, and not all of this would be seen were the front margin of the pronotum intact. The latter has been broken away in the middle line, and allows a portion of the head to become visible. The hinder part of the head is well rounded and narrowed, the front being wide, and having a forward and downward slope. It is finely tuberculated. A small aperture in the middle of the head may be due to a loss of matrix.

The pronotum is attached to that half of the nodule which contains the wing-impressions, and the hinder border is still covered with the matrix. Its whole contour cannot be seen, and only the inner surface is exposed. It is semi-circular, with a well-defined margin, 12 mm. wide, and 8 mm. long from front to

back. The central area has a deep median furrow, and is marked off from the lateral halves by two ridges (representing the furrows on the dorsal surface). These ridges converge anteriorly and almost meet. The inner surface is slightly concave, and indented by three faint furrows on each side, parallel with which are traces of fine striations.

The mesonotum is 4·5 mm. long, and much wider anteriorly than posteriorly. It is convex, and the hinder border has a raised rounded edge. It is strongly chitinous, much more so than the metanotum, which is crushed down beneath the anal areas of the tegmina, only a little of the hinder portion of the left side showing at one point where the anal areas of the wings have been broken away. The right tegmen lies in the position of rest, its inner margin being in line with the axial line of the body. The left tegmen was rotated outwards to a slight degree before entombment—a feature which, combined with the breaking away of its distal third, has enabled the left hind-wing to be better shown. The right tegmen has a length of 33 mm. and a breadth of 13 mm.

The costal margin is moderately thickened, convex, and merges gradually into the wing-apex, the latter bluntly rounded.

The subcostal vein is thin, and encloses a long strap-shaped area, crossed by 9—10 oblique branches, most of them forking twice before reaching the margin.

The radius is a strong vein, nearly parallel with the subcosta, and ending on the outer margin in four small branches, the second only forking. The radial sector arises just before the middle of the wing, diverging but slightly from the radius. It gives off three short outward branches to the apex.

The main stem of the median passes along the middle line of the wing for some distance, and curves inwards to the distal end of the inner margin. The first outward branch arises a little beyond the middle of the wing, and forks into two equal-sized twigs; the remaining two branches remain undivided to the broken edge of the wing. The median and its subdivisions occupy the centre and inner half of the wing-apex.

In the left tegmen the second branch of the median forks. The cubitus is strongly convex in the proximal two-thirds, and bends forwards in the distal third and inwards again to the inner margin. It gives off six inward branches, the fourth and fifth forking before reaching the margin. The anal veins are eight in number, three being very small and short. The first forks twice, and the second once. The inner margin is almost straight. The interstitial neuration is made up of straight nervures. The surface of the tegmina is chitinous.

The hind-wings appear not only to have been covered by the tegmina, when they were in a position of rest on the body, but to have stretched a little beyond them like a fringe.

The left hind-wing is thin and membranous, and marked by numerous veins, the bases still hidden under the tegmen. A little of the distal portion of the

costal margin is shown, passing into a very broad and expanded apex. The subcosta reaches nearly to the end of the costal margin, and gives off numerous oblique and forked branches. Immediately behind the subcosta is a stout vein with two outer branches, both forking. This vein seems to be the radius. Its basal extension under the tegmen can be traced by a raised line. Behind the radius are two stout veins, each of which forks into equal-sized twigs some distance from the margin. Their position justifies the inference that they unite proximally and join the radius, in which case they must belong to the radial sector. The median is a doubly forked vein. The remainder of the wing is either bent under, or folded upon itself, and further details cannot be made out.

Affinities.—The species differs from *Aphthoroblattina johnsoni* in several important details. The radial sector arises further out, and instead of forking twice, gives off three simple forward veins. The median forks three times, the proximal branch forking again before reaching the wing-apex. In *A. johnsoni* there are two branches, both of which fork. The cubitus vein differs considerably owing to the fact that the main stem divides at the outer third into two branches of equal strength, the outer immediately forking again into two equal twigs, while the inner gives off a small inner twig. No definite outer branches are distinguishable. A strong anal furrow is present, and the first anal vein on both sides divides into three twigs, the remaining 5—6 anal veins being undivided.

Genus **ARCHIMYLACRIS**, Scudder.

1868. *Archimylacris*, Scudder, in Dawson's Acadian Geology, ed. 2, p. 388.

Generic Characters.—Tegmina twice as long as wide, with convex outer margin. Inner margin concave. Radial sector arising in basal half of wing. Anal veins few, anal area large. Neuration of abundant stout straight cross-nervures.

Archimylacris hastata, Bolton. Plate VII, fig. 1; Text-figure 33.

1911. *Archimylacris* (*Etoblattina*) *hastata*, Bolton, Quart. Journ. Geol. Soc., vol. lxvii, p. 160, pl. ix, figs. 1—3.

Type.—The greater part of a left tegmen and its counterpart, showing the upper surface; Museum of Practical Geology, Jermyn Street (nos. 24501 and 24502).

Horizon and Locality.—Upper Coal Measures (Gellideg Level of the Mynydd-islwyn Vein); near Maes-y-cwmmer, Monmouthshire.

Specific Characters.—Wing broadly elliptical. Costal margin convex; costal area broad at base and stretching beyond the middle of the wing. Subcosta with numerous branches, all oblique. Radius forking twice, and ending near

apex of wing. Median branching further out than the radius. Cubitus reaching margin in distal third of wing. Anal veins numerous. Inner margin almost straight.

Description.—A portion of the base of the wing and a considerable part of the apical and inner margin are missing, but the length preserved is 33·4 mm. and its breadth is 16·5 mm.

The wing is strongly outlined, especially along the outer margin, partly owing to a broad concave depression which runs almost the whole length of the subcostal and radial areas, causing the anterior margin to be reflexed dorsally. The inner margin is preserved only along a portion of the anal border, and the inner two-thirds of the wing-apex are also missing. Sufficient is left of the apex to show that it must have been bluntly rounded.

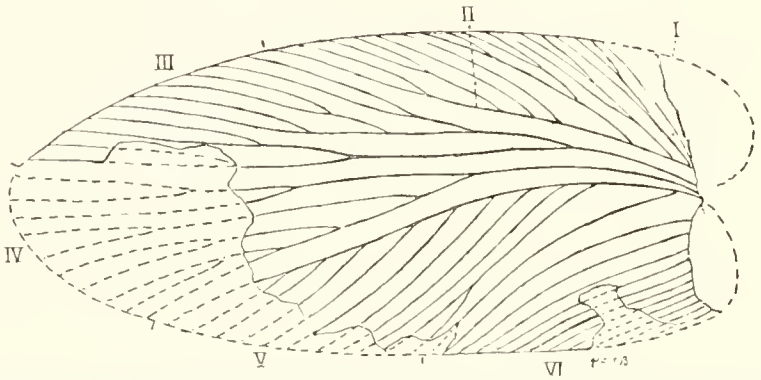


Fig. 33.—*Archimylacris hastata*, Bolton; diagram of venation of left fore-wing, three times natural size.—Upper Coal Measures (Gellideg Level of the Mynyddislwyn Vein); near Maes-y-cwmmer, Monmouthshire. Mus. Pract. Geol. (nos. 24501, 24502). Lettering of veins.—I. costa; II. subcosta; III. radius; IV. median; V. cubitus; VI. anal.

The subcostal vein passes out obliquely from the point of attachment and reaches into the distal third of the wing. It gives off 9—10 very oblique branches, the basal three forking twice, the next two undivided, and the last branch but one forked. The subcostal area is broad basally, and terminates in an acute angle distally.

The actual origin of the principal veins is lost, and the radius appears at its origin therefore to be widely removed from the subcosta. It follows a parallel course to the origin of the first anterior branch, and afterwards diverges, so that it finally ends on the apex of the wing near the middle line. The first branch is important, forking three times in its course and ending in six divisions. The second branch forks only once.

The subcosta and radius together occupy a little less than half the whole wing-area. Dr. Pruvost supposes that a commissural branch unites the radial sector and the median in this species (1919, 'Mémoires pour servir à l'Explication de la Carte Géologique Détaillée de la France,' p. 151), but I cannot perceive this.

The median vein arises in actual contact with the stem of the radius, or is

united with it, rapidly diverging to the distal part of the inner margin. Four branches are given off on the outer side, the first forking before the broken edge of the wing is reached. The remaining three probably forked also on the missing part of the wing-apex. The subdivisions of the median occupy the inner half of the wing-apex, and the apex itself.

The regularity of arrangement of the minor veins is a marked feature of this wing, and lends colour to our supposition.

The cubitus gradually diverges from the median along the whole of its course. Ten branches are given off on the inner side, the first only forking.

The anal area is sharply marked off from the rest of the wing by a deep anal groove, the anal area being elevated and somewhat convex in outline. Ten to eleven anal veins can be distinguished, the marginal ones being very short and feeble.

The interstitial neuration consists of close, strong, transverse nervures so numerous as to give the wing-surface a finely corrugated appearance.

The tegmina were apparently of great strength, the unusual development of the transverse nervures adding to the rigidity, while the presence of an oblique ridge served to support and strengthen the radius, median and cubitus at their base, and a similar ridge gave support to the whole of the anal area.

Affinities.—In 1911 (*loc. cit.*) I gave reasons for regarding this species as an Archimylacrid, comparing it with *A. spectabilis*, Goldfuss, and *A. venusta*. More recently, Dr. Pruvost ('Ann. Soc. Géol. Nord,' vol. xli, p. 335, pl. ix, figs. 4—4 *a*, 1912) has expressed the opinion that it is so nearly like *A. belgica*, Handlirsch, and a specimen he has himself described from the roof of the Alfred Vein, Liévin, Northern France, as to be referable to that species. An examination of the figures published by Handlirsch and Pruvost does not support this view. *Archimylacris belgica* was founded by Handlirsch ('Mém. Mus. Roy. Hist. Nat. Belg.,' vol. iii, p. 12, pl. iv, figs. 17—18, 1906) on a wing in the Brussels Museum, from the Westphalian or Middle Upper Carboniferous of Jemappes, Belgium. It was afterwards transferred by him to a new genus, *Parelthoblatta* ('Die Fossilen Insekten,' p. 184, pl. xviii, fig. 54, 1906). This new genus is not accepted by Pruvost, who considers that it is founded chiefly on the pectinate character of the first branch of the radius. He therefore replaces the species in the genus *Archimylacris*, and refers his own specimen to the same genus and species. With this conclusion I cannot agree. Handlirsch's species is characterised not only by the pectinate character of the first branch of the radius, but (and much more important) by the presence of a meshwork of interstitial neuration between the radius, median and cubitus. This latter feature clearly separates not only the French specimen from Handlirsch's genus *Parelthoblatta*, and therefore from *P. belgica*, but the British specimen also; for in both the interstitial neuration consists wholly of a close series of straight cross-nervures, with not the slightest trace of the development of a network.

A. hastata is closely allied to the French species, but the divisions of the main veins are fewer and of a more simple nature. I see no reason to remove the British species from the genus *Archimylacris*, and would refer the French example also to the same genus. This view is now accepted by Pruvost (*loc. cit.*, p. 158).

Archimylacris woodwardi, Bolton. Plate VII, fig. 2; Text-figure 34.

1910. *Archimylacris* (*Etoblattina*) *woodwardi*, Bolton, Geol. Mag. [5], vol. vii, pp. 147—151, pl. xv, figs. 1—1 *a*.

Type.—A left tegmen or fore-wing, 18 mm. long and 10 mm. wide; collection of Mr. D. Davies, F.G.S.

Horizon and Locality.—Coal Measures (a ten-foot shale overlying the No. 2 Rhondda Seam, base of the Pennant Series); Clydach Vale, South Wales.

Specific Characters.—Wing short and broad. Apex well rounded and merging

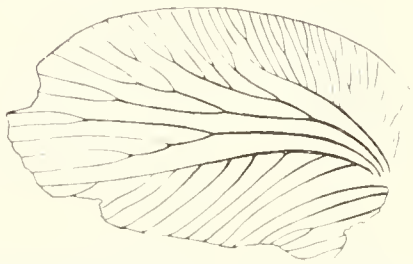


Fig. 34.—*Archimylacris woodwardi*, Bolton; diagram of wing-venation of left fore-wing, three times natural size.—Base of Pennant Series (roof of ten-foot shale overlying the No. 2 Rhondda Seam); Clydach Vale, South Wales. David Davies Collection.

into costal border. Anal area convex. Interstitial nemration of abundant stout cross-nervures, occasionally uniting laterally.

Description.—The tegmen, which is short, broad and strongly chitinous, lies with the convex dorsal surface uppermost. The well-rounded outer margin of the wing merges into the equally well-rounded apex. The inner margin is nearly straight, a slight hollowing only of the middle portion being shown. Notwithstanding its small size, the details of the wing are very clear, the veins and the interstitial neuration being well shown. The basal portions of the main veins are elevated above the surface, the rest of their length and also their divisions being sunk below the general level.

The subcostal vein is weak, and sunk along its whole course. It is widely separated from the costal margin, following a parallel course to beyond the middle of the wing, where it bends outward and joins the margin. The subcosta gives off a numerous series of forked and simple divisions to the costal margin.

The radius arises close to the subcosta and median, diverging from the former in the middle of its length, and approaching it again by the first of the four outer

branches which it gives off. The first two branches of the radius are forked, the rest undivided. The radius with its divisions occupies the distal third of the wing-margin. At the junction of the basal and middle thirds of the wing, the radius gives off a strong radial sector which diverges from it, giving off two outer branches, the first forking twice into four twigs. The radial sector occupies the outer half of the wing-apex.

The median curves regularly inwards along its whole course, reaching the inner end of the wing-apex, and giving off three outer branches, of which the first is forked. With its subdivisions it occupies a much less area than any other main vein.

The cubitus follows a course nearly parallel with the median, and gives off nine inward branches. With its subdivisions, it occupies almost the whole of the distal two-thirds of the inner margin.

The anal area is strongly convex, and crossed by at least five anal veins, the third being forked.

The interstitial neuration is well developed in the neighbourhood of the subcosta, and consists of a close-set series of straight cross-nervures. These are in relief, and in places seem to unite laterally, and to cross the main veins.

Affinities.—The wing is typically Archimylacrid. At the time of its discovery in 1910 I was unable to show that it possessed a close relation to any known species, but more recently Dr. Pruvost has recorded a very similar example, *A. atrebatica*, Pruv., from the Coal Measures of Bruay, Northern France.

The presence of a well-defined radial sector is a Palæodictyopteroid feature which most Blattoids have lost, and stamps the species as primitive. It is therefore interesting to find that Pruvost draws special attention to the fact that *A. atrebatica*, Pruv., is the oldest Archimylacrid of the Northern French Coal Measures, being found in the lower portion of the Formation of Bruay, over the vein Ernestine at Lens, in a shale containing seeds and drifted plant-remains.

Archimylacris incisa, sp. nov. Plate VII, fig. 3.

Type.—Pronotum, mesonotum, and the basal portions of the tegmina in an ironstone nodule; British Museum (Johnson Collection, no. I. 15900).

Horizon and Locality.—Middle Coal Measures (binds between the "Brooch" and "Thick" coals); Coseley, near Dudley, Staffs.

Specific Characters.—Wing robust. Principal veins widely spaced. Interstitial neuration of stout cross-nervures, which unite in a meshwork in the wide areas.

Description.—These Blattoid remains are 21 mm. long. The pronotum lies with its underside uppermost on that portion of the nodule which also bears the impressions of the under surfaces of the tegmina, while the impression of the underside of the pronotum and the fragments of the tegmina upside down occur

on the other half. The hinder margin of the pronotum is still hidden in the matrix, and the impressions of the under-surfaces of the wings would need to be destroyed to expose it.

The pronotum is semicircular in outline, so far as can be determined. The inner surface is marked out into two lateral areas which join in front of, and behind, the central area, the latter being hollow, probably to lodge the head of the insect during life. The central hollow of the pronotum is crossed in front and behind by close-set parallel wrinkles, while a suture-like crack traverses the whole structure in the middle line. Posteriorly to the central hollow, the lateral halves have separated and become wrinkled up against each other.

The condition of the pronotum shows that it was convex, the central hollow of the inner surface marking off an area which was more convex than the sides, and separated from them by grooves which bent round and joined behind the central more elevated area. The central area is thinner than the sides and infolded.

Lying behind, and partially overhung by the hind border of the pronotum, is a heart-shaped structure, irregularly indented, owing its superficial appearance to the overlap of the anal areas of the wings on it. On one side of this structure can be seen what appears to be part of a stout segment, having a thickened anterior border, and a convex surface bearing a few low tubercles. The central indented structure occupies the position of the mesonotum, and the lateral stouter segment may be a part of it, or of the metanotum which has been pushed forward.

The base of the left tegmen is in actual articulation with what I suppose to be the mesonotum. As the tegmina lie with their under surface uppermost, the impressions on the opposite half of the nodule are also of the same surface.

The fragment of the left tegmen is largest, and in the best condition, but not more than a third of it is present. The tissue is thickly chitinous, much more so than that of the pronotum.

The costal margin is convex, and the costal area strap-shaped and wide. Seen from the underside it appears smooth, a few diagonal wrinkles alone crossing the surface. We may therefore infer that the divisions of the subcosta are weakly incised on the upper surface.

The subcostal vein is more convex in direction than the margin, the costal area being widest at the base.

The radius arises close to the subcosta, and gradually diverges from it. It shows no divisions in the basal portions preserved.

The median vein arises even closer to the radius than does the latter to the subcosta, and bends inwards in a convex curve for some distance, afterwards flattening and becoming parallel with the radius.

The cubitus arises closer to the anal furrow than to the median, but bends outwards in a bold sweep away from it, becoming almost parallel with the median. It gives off three inward branches in the part preserved, the first low down near

the base, and the remaining two at wide intervals further out. The course of the main stem is such as to indicate that it reached the distal portion of the inner margin, so that the wing-apex was wholly occupied by the divisions of the radius and the median.

The anal veins seen are five in number, the first forking twice and the rest single. They probably occupied the proximal third of the inner wing-margin.

The articulation of the tegmen to the mesonotum seems to have been strengthened by the formation of three ridges, two formed by the deepening of the bases of the subcosta and radius, and a third by a similar thickening just inside the anal furrow, which in this specimen coincides with the line of the first branch of the cubitus.

The basal part of the subcostal area shows a deep hollow; this feature is seen in several of the British Blattoids, and favours the assumption that while the point of attachment lay immediately behind, the frontal part of the mesonotum developed an area which served as a fulcrum for the tegmina.

The right tegmen is represented only by the base of the costal border and subcosta, short portions of the radius, median, a part of the cubitus with two proximal branches, and the inner anal vein dividing into three.

The interstitial neuration consists of strong cross-nervures, frequently uniting laterally, and on the broader areas forming a slight open meshwork.

Affinities.—Fragmentary though the wing is, it yet shows many of the features of *A. venusta*, Scd., having the same wide costal area, the same relation of subcosta, radius and median so far as these can be traced, and the cubitus beginning to branch low down before the radius and median show any trace of branching. The interstitial neuration in both consists of straight cross-nervures occasionally uniting laterally.

This wing is more robust than that of *A. venusta*, Scd., and the anal veins are more oblique in direction. The whole of the main veins and those of the anal area are more widely spaced. In its robust character the wing approaches *A. acadica*, Scd., but in that species the interstitial neuration does not unite laterally.

Archimylacris (Schizoblatta) obovata, Bolton. Plate VII, fig. 4; Text-figure 35.

1911. *Archimylacris (Schizoblatta) obovata*, Bolton, Quart. Journ. Geol. Soc., vol. lxvii, p. 157, pl. vii, figs. 4–6.

Type.—The distal two-thirds of a left tegmen, having a length of 23 mm. and a greatest breadth of 10 mm.; Museum of Practical Geology, Jermyn Street (nos. 24506 and 24507).

Horizon and Locality.—Base of the Upper Coal Measures (Gwernau Level of the Mynyddislwyn Vein); Macs-y-cwmmer, Monmouthshire.

Specific Characters.—Costal border moderately convex, and passing into a

subacute apex. Costal area narrow and strap-shaped. Subcosta extending just beyond the middle of the wing. Radius large, much divided, and occupying the distal portion of the outer margin, and the outer half of the apical margin and apex. Median a small vein with few divisions ending on the inner apical margin. Cubitus occupying the whole of the inner margin beyond the anal veins. Surface covered with a close series of oblique wrinkles.

Description.—When I first described this specimen in 1911, I was of opinion that the length of the complete wing was not more than 25 mm. With a larger knowledge of the structure and form of the Blattoid tegmen I should now estimate the length at nearer 35 mm., the complete structure being a little over two-and-a-half times as long as broad.

The costal border is broadly convex, more so in the distal than in the proximal half.

The subcostal area is narrow, the subcosta being a delicate vein, sending a number of forked and simple branches obliquely to the costal margin. Probably half of the subcosta is missing, though three branches of it are present. One

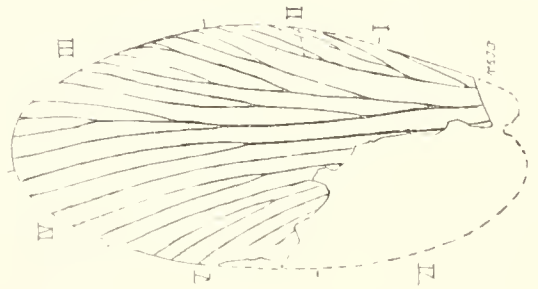


FIG. 35.—*Archimylacris* (*Schizoblatta*) *obovata*, Bolton; diagram of venation of left fore-wing, three times natural size.—Upper Coal Measures (Gwernau Level of the Mynyddislwyn Vein); Maes-y-cwmmer, Monmouthshire. Mus. Pract. Geol. (nos. 21506, 24507. Numbering of veins as in Text-figure 33, p. 104.

remains single, the next gives off a simple basal twig, and forks just before reaching the margin, while the outer branch is undivided.

The radius is much the largest of the principal veins, and is widely separated from the subcosta over the middle portion of its length. Before reaching the middle of the wing it divides into two diverging branches, each of which forks, and afterwards gives off a series of smaller veins, eleven in number, which occupy the distal outer margin, and the outer half of the wing-apex.

The median vein is not complete, and seems to consist of a main stem, giving off a long branch in the basal third of the wing, a second branch in the middle, and a final branch in the outer third. The first branch only divides, so that the median ends on the inner apical margin in five divisions.

The remaining marginal veins are probably wholly cubital. They are five in number, one only forking.

There is no trace of the anal portion of the wing, or of the remainder of the cubitus.

The wing is thick, coriaceous in texture, and convex dorsally. The whole surface is covered by a dense series of irregular oblique wrinkles. In some places a close-set series starts out from the sides of a vein, and dies out in the interspace. In other places sets of wrinkles are interrupted by smooth interspaces, this arrangement occurring at haphazard. There are a few cases in which the wrinkles unite.

Affinities.—There can be no doubt as to this specimen representing an Archimylacrid. Dr. Handlirsch, who makes *Archimylacris* the type of a family, Archimylacridæ ('Proc. U.S. National Museum,' vol. xxix, p. 722, 1906), has also founded a new genus, *Schizoblatta*, and with the type-species of this genus the specimen here described is in close agreement.

The points to which I attach importance are the following: In both, the subcostal area extends for a short distance beyond the middle line, the veins in each case passing out obliquely to the margin. A very wide interval separates the stem of the subcosta from that of the radius in the middle of their length, and this area is narrowed distally in each case by the approach of the marginal veins. The radius is a large and much branched vein, and separates into two main divisions, which fork at the same level and reach the apical point of the wing—in this specimen just beyond it. The median is relatively small, while the cubitus has few branches, passing obliquely out, like those of the subcosta, to the margin.

The anal area in the type, *Schizoblatta alutacea*, is long, attaining nearly half the length of the wing. In the specimen here described this part is missing, as is also a part of the cubitus. The missing portion of the inner margin extends beyond the middle of its length, and knowing how frequently the anal vein determines the line of fracture, this extended broken area becomes significant.

Dr. Handlirsch's definition of the genus *Schizoblatta* is as follows: "Front wing elliptical, about two and two-fifth times as long as broad. Costal area extending about three-fifths the length of the wing, with about nine or ten normal veins; not expanded at the base. Radius divided into two principal stems, the superior of which separates into six branches and the inferior into eight, the majority of the latter ending in the apical border. The median likewise divides into two main stems, the anterior of which forms five branches, and the posterior four, all of which fuse in the apical margin. The eight branches of the gently vaulted cubitus take up the entire inner border. The anal area attains nearly half the length of the wing. Cross-veins area not to be distinguished, but instead there is a fine-grained leathery structure" (*loc. cit.*).

If the genus is to be maintained apart from that of *Archimylacris*, I would base the characters on the obliquity of the marginal veins of the subcosta and cubitus,

the presence of a wide interval between the former and the radius, and the wide area occupied by the latter.

The division of the radius into two unequal branches, with its symmetrical double bifurcation, is also, I venture to think, a feature of primary importance.

In the wide divergence of the radius and median, this species agrees with Scudder's genus *Spiloblattina*; but in this case the veins do not converge again to enclose an elongated or oval area.

Archimylacris, sp. indet. Plate VII, fig. 5.

1911. *Archimylacris*, sp. indet., Bolton, Quart. Journ. Geol. Soc., vol. lxvii, p. 163, pl. x, fig. 3.

Type.—A fragmentary wing, lacking the apex and the base; Museum of Practical Geology, Jermyn Street (no. 24503).

Horizon and Locality.—Base of Upper Coal Measures (Gellideg Level of the Mynyddislwyn Vein); near Maes-y-cwmmer, Monmouthshire.

Description.—The specimen is much too fragmentary for any attempt at specific determination. A portion of the distal margin is present, with three branches of the subcosta. These are succeeded by eight straight veins, two at least forking, which belong to the radius and median series. These are followed by an equal number of veins partially hidden by the surface of the integument, which is much wrinkled over this area. These, I assume, are parts of the cubitus vein. The wrinkling of the integument over the cubital area is very marked.

The special interest of this wing-fragment is in its association with portions of a leaf of *Cordaites*. Scudder and others have commented on the general association of the wings of Blattoids with leaves of *Cordaites*, but have not, so far as I am aware, drawn attention to a feature which is well shown by this leaf, namely, pits on its surface. I have repeatedly found such depressions on the leaves of *Cordaites* in the Lancashire Coalfield, and in many cases seen the hollows occupied by the shells of *Spirorbis pusillus*. The shallow pits on the *Cordaites*-leaf associated with this fragmentary wing show faint traces of a spiral, similar to the impression of *Spirorbis*, and such shells were, I think, once attached to it. While the Carboniferous Blattoids may have been wholly phytophagous, we are led by our knowledge of the living Blattids, especially by the common cockroach (*Periplaneta orientalis*), to assume the contrary, and to regard them as more likely to have been omnivorous, in which case the association of Blattoid remains with the leaves of *Cordaites* bearing the sedentary *Spirorbis* is easily understood. The association also lends support to the belief that the Blattoids were semi-aquatic in habit, or lived in marshes and swamps in which decayed vegetation formed a home for *Spirorbis*.

Archimylacris, sp. indet. Plate VII, fig. 6.

1911. *Archimylacris*, sp. indet., Bolton, Quart. Journ. Geol. Soc., vol. lxvii, p. 152, pl. vii, fig. 2.

Type.—Impression of basal portion of left tegmen; Museum of Practical Geology, Jermyn Street (no. 24508).

Horizon and Locality.—Base of Upper Coal Measures (Mynyddislwyn Vein, Gellideg Level); near Maes-y-cwmmer, Monmouthshire.

Genus **PHYLOBLATTA**, Handlirsch.

1906. *Phyloblatta*, Handlirsch, Bull. U.S. Nat. Mus., vol. xxix, p. 738.

Generic Characters.—Tegmina elliptical, two-and-a-quarter to two-and-a-half times as long as wide; costal area strap-shaped, rarely wide, and extending usually to three-fifths or two-thirds the length of the wing; not expanded basally. Radius with numerous branches, all of which reach the outer margin. Median with outer branches only, reaching wing-apex. Cubitus large, much branched, and occupying distal two-thirds of inner margin. Anal area large with numerous veins. Interstitial neuration rugose leathery or much cross-wrinkled.

Phyloblatta sulcata (Bolton). Plate VIII, fig. 1; Text-figure 36.

1911. *Gerablattina* (*Aphthoroblattina*) *sulcata*, Bolton, Quart. Journ. Geol. Soc., vol. lxvii, p. 165, pl. viii, figs. 1—3.

Type.—Greater part of tegmen and its counterpart impression showing the under surface only; Museum of Practical Geology, Jermyn Street (nos. 24504 and 24505).

Horizon and Locality.—Base of the Upper Coal Measures (Gwernau Level of the Mynyddislwyn Vein); near Maes-y-cwmmer, Monmouthshire.

Specific Characters.—Costal area broad; subcosta strap-shaped, and extending far out. Radius with six branches, occupying outer half of wing-apex. Median with few divisions and occupying a small area of the wing. Cubitus united with median at the base. Anal furrow well developed. Anal veins 5—8.

Description.—The specimen comprises the greater part of a right tegmen, showing the under surface, the counterpart impression being on a second piece of black shale. An irregular narrow fringe of the wing-membrane has been lost along the outer and inner margins, and the inner half of the wing-apex is also missing. The length of the fragment is 35 mm., and the greatest width 16 mm., the perfect wing being probably about 45 mm. long, and 22—23 mm. wide. If this estimate is correct, the wing is short. Tegmina are usually at least two-and-a-half

times as long as wide. The structure is well preserved, and the principal veins and their subdivisions are in relief.

The costal margin is thickened, strongly convex, and well rounded at the base. The costal area is unusually broad and strap-shaped, extending over two-thirds of the costal margin. The basal portion of the costal area is smooth, and not crossed by branches of the subcosta.

The subcosta is thin, elevated basally, and somewhat crenulated, doubtless owing to post-mortem change or pressure. The subcosta is parallel with the costal margin over more than one-half the length of the wing, and gives off six oblique branches to the margin. Three of these branches are forked.

The radius passes out to the apex of the wing, giving off six outer branches, the first forking once, and the second twice before reaching the margin. The

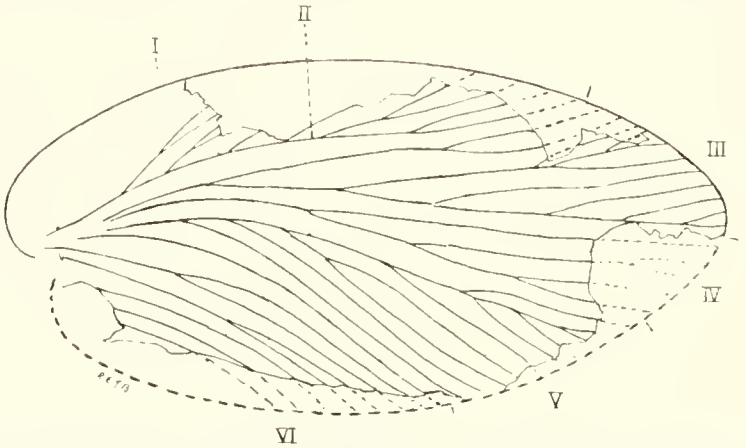


FIG. 36.—*Phyloblatta sulcata* (Bolton); diagram of the venation, and restored outline of fore-wing, two-and-a-half times natural size.—Upper Coal Measures (Gwernau Level of the Mynyddislwyn Vein); near Maes-y-cwmmer, Monmouthshire. Mus. Pract. Geol. (nos. 24504, 24505). Numbering of veins as in Text-figure 33, p. 101.

remaining branches are undivided. The radius and subcosta together occupy a little less than half the total wing-area.

The median vein is convex outwards in its basal half, and then bends inwards to the junction of the inner and apical margins. It gives off three long, outward, undivided branches, all of which are parallel with the main stem of the radius. Basally, the median curves sharply inwards and unites with the cubitus, the two veins having a very short common stem.

The cubitus is the largest and most important vein in the wing, although but faintly outlined at the base, where its union with the median is nevertheless quite clear. It gives off seven inwardly directed branches, the third only forking. On its outward side two branches are given off.

The anal furrow is represented by a strong ridge, and is therefore a well-marked groove on the dorsal surface of the wing. The anal area is large, extending at least one-third the length of the inner margin, and crossed by five

anal veins, the first and second only being forked. The whole of the anal area is not shown, and 3—4 veins may be missing.

The interstitial neuration consists of a close series of transverse nervures or wrinkles, it is impossible to say which. They are best seen in the anal and cubital areas.

Affinities.—The union of the stems of the median and cubitus veins, the occupation of the greater part of the inner half of the wing by the median, whose branches take up the whole of the inner margin outside the anal area, and the strong parallelism of the branches of the principal veins, are well-marked features which in the main agree most, I think, with *Phyloblatta*. Its resemblance to *Gerablattina* is also marked, and it is well to remember that Handlirsch has referred several species originally placed in the latter genus to *Phyloblatta*. This question of the generic relationship is a good example of the difficulty of allocating species to genera whose characters are not wholly known.

Phyloblatta transversalis, Bolton. Plate VIII, fig. 2; Text-figure 37.

1917. *Phylloblatta transversalis*, Bolton, Proc. Birmingham Nat. Hist. Phil. Soc., vol. xiv, pp. 100—103, pl. vii, figs. 1, 2.

Type.— Remains of two Blattoids, consisting of the tegmina, two pronota, and portions of the hind-wings, in a split nodule of ironstone, 60 mm. long, and 45 mm. broad; Geological Museum, University of Birmingham.

Horizon and Locality.—Coal Measures; Staffordshire.

The nodules were collected by Dr. Blake and agree in all respects with those found at Tipton and Coseley, Staffordshire, in the binds between the "Brooch" and "Thick" coals of the Middle Coal Measures.

Specific Characters.—Radius relatively simple with five branches, radial sector large and evenly forked; median vein small, with three outer branches; cubitus vein long with seven inward branches; anal area small with few anal veins.

Description.—The remains of three insects are shown on the split surfaces of two small ironstone nodules. The larger nodule contains the remains of two Blattoid tegmina, two pronota, and fragments of hind-wings. One tegmen is almost complete, while of the other more than half is shown, the distal end having been lost in splitting the nodule.

The tegmina lie with the under surfaces uppermost, the impression of the underside being preserved on the larger portion of the nodule. As both are from the left side, it follows that they belong to two insects—a conclusion confirmed by the presence of a pronotum in close association with each. In the case of the more nearly complete tegmen, the pronotum lies a little apart, and upside down, like the tegmen, while the pronotum of the more incomplete wing lies on the basal

portion of the tegmen itself, and has the dorsal surface uppermost. Traces of hind-wings are present, lying on a slightly lower plane than the tegmina, and showing only the underside.

As the two tegmina are specifically identical, the more nearly complete example has been taken as the type and is here described in detail.

The tegmen has a length of 32 mm., and, as a small part of the apex is missing, its total length must have been about 35 mm. The width is uniform over the basal half of the wing, and averages 11·5 mm.

The costal margin forms a strong convex curve, in this respect contrasting with the inner margin, which is nearly straight. The wing-apex is directed backwards owing to the great convexity of the costal margin. The whole wing has a broad semilunate appearance.

The subcosta is a feeble vein, not easily discernible; its outwardly-directed twigs pass out obliquely, and are twice or thrice forked. Like the main stem, they are faintly impressed, and cannot be traced up to the costal margin. Eight twigs can be determined. The subcostal area is strap-shaped, and extends beyond the middle of the wing.

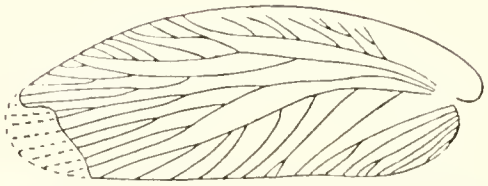


Fig. 37.—*Phyloblatta transversalis*, Bolton; diagram of venation of left fore-wing of type-specimen, twice natural size.—Middle Coal Measures; Staffordshire. Geol. Mus. Univ. Birmingham.

The radius is a strong vein, and shows an inner sub-division which has all the characters of a radial sector. Basally, it seems joined to the median, but it is an apparent junction only, the wing-base being pressed in upon itself, and bringing the two close to one another. After giving off the inner (radial sector) branch, the radius gives off five outer branches which reach the distal third of the outer margin. The first of these branches seems to break up into three twigs, but the structure of the wing is not clear at this point. The radial sector, which arises in the basal half of the wing, forks at the distal third into two equal branches, the outer forking twice into four divisions, and the inner forking once. The radius and radial sector occupy the whole of the outer half of the wing-apex.

The median vein diverges from the radius along its whole course, and reaches the distal end of the inner margin, giving off three outer branches in the distal half of the wing. These pass straight to the apex, the first forking twice, and the second once, the third remaining undivided to the broken edge of the wing. The branches of the median occupy the whole of the inner half of the wing-apex.

The eubitus remains above the middle line of the wing in the basal third, curving inwards and flattening in the outer two-thirds of the wing, and giving off seven inward branches, the second alone forking low down near the margin.

The anal area is small, and crossed by six oblique anal veins, the first and third of which fork.

The interstitial neuration consists of a close-set series of straight cross-nervures which unite laterally as they cross the wider areas.

The pronotum in close apposition with this wing has its inner surface uppermost. This shows a central shallow concave area, bounded by two lateral ridges, which die away as they approach the hinder border. The general outline is broadly circular.

The second tegmen is much less exposed than the first, and has its apex buried under the second pronotum. So far as its structure can be determined, it agrees with the wing already described.

The second pronotum has been crushed, the anterior border being turned round upon the base of the wing, and partly broken away. The posterior margin is almost straight, and that of the anterior well rounded.

Traces of two hind-wings are shown, one a little in advance of the more nearly complete wing, and partly underlying it, and the other underlying the costal and radial areas of the second incomplete wing. The first hind-wing shows a portion of the distal extremity, with a series of incomplete veins, probably belonging to the radius, median, and eubitus; the remains of the second hind-wing probably consist of the distal radial twigs only.

Affinities.—The distinguishing features of the tegmina are essentially those of *Phyloblatta*, unless we except the interstitial neuration. This is composed of straight cross-nervures, which unite laterally across the wide areas between the main stems of the radius, median, and eubitus, but not producing anywhere a meshwork such as is usually seen in the Phyloblattids.

Handlirsch doubts the presence of a cross-neuration in the genus *Phyloblatta* (‘Proc. U.S. National Museum,’ vol. xxix, p. 731, 1906), but there seems no reason why it should not be present in the more archaic members of the genus, as they all have an Archimylacrid ancestry, in which a cross-neuration is a dominant feature.

The species is closely allied to a form figured as *Gerablattina* sp. by Brongniart (‘Insectes Fossiles des Temps Primaires,’ pl. xlvi, fig. 7, 1893), and repeated by Handlirsch (‘Die Fossilen Insekten,’ pl. xxx, fig. 35, p. 295, 1906) under the name of *Blattoidea*, sp. Handlirsch regards Brongniart’s specimen as belonging either to the Spiloblattinidæ or to the Archimylacridæ. Unfortunately the interstitial neuration is not shown. If, as in these specimens, Brongniart’s species possesses a cross-neuration, or one in which the nervures unite laterally, it must be referred to *Phyloblatta*.

(Archimylacridæ) kirkbyi (Woodward). Plate VIII, fig. 3.

1887. *Lithomylacris kirkbyi*, Woodward, Geol. Mag. [3], vol. iv, p. 55, pl. ii, figs. 4*a*—4*b*.
1887. *? Hermatoblattina kirkbyi*, Scudder, Proc. Bost. Soc. Nat. Hist., vol. xxiii, p. 357.
1906. (*Archimylacridæ*) *kirkbyi*, Handlirsch, Die Fossilen Insekten, p. 238, pl. xxiv, fig. 37.

Type.—Left wing (tegmen); formerly in the collection of the late Mr. James Kirkby.

Horizon and Locality.—Upper Coal Measures (bed No. 33); near Meithil, coast of Fifeshire.

Description.—Our knowledge of this wing depends on the description and figures published by Dr. H. Woodward. His description is as follows: "Outline of wing pointed-ovate, slightly flattened on its superior border; length of wing 15 mm., breadth 8 mm. The 'mediastinal' [subcostal] vein occupies rather more than a fourth of the entire area of the wing; it extends to about two-thirds of the length, where it unites with the superior margin of the wing; it branches six times; one of these branches has three forks. The 'scapular' [radius] vein extends nearly to the extremity of the wing; it remains single for over one-fourth of its length, and then branches into three veins, the middle one of which is again forked. The 'externo-median' [median] vein continues parallel to the scapular vein for a slightly longer distance before it branches at the extremity of the wing into three inferior veins, two of which are again forked. The 'interno-median' [cubitus] vein occupies about one-fourth the entire area of the wing; it gives off three almost equidistant branches, none of which appear to be forked. The anal vein is nearly straight, and has three other almost parallel oblique simple veins occupying the anal area."

Affinities.—Neither Woodward's figures nor the later modified drawing published by Handlirsch are very helpful in enabling us to identify the genus. Handlirsch has reversed the figure given by Woodward, and shows three veins which may belong to the subcosta, a radius with three forward branches, and a well-divided median ending on the wing-apex in nine outer branches. Woodward's "mediastinal" becomes the cubitus, and no anal veins are shown. This seems a more reasonable interpretation of the wing.

Woodward's comparison of the wing with *Lithomylacris pittstonianum*, Scd., is unfortunate, as in that species the radius is a large, much-branched vein, occupying nearly half the outer margin, while the radius (scapular) in *A. kirkbyi*, Woodw., has three divisions only as shown by him, although it is a more branched structure when the figure is reversed and the veins reconsidered, as by Handlirsch.

In the absence of the type-specimen, it is not possible to do more than refer the species to the family Archimylacridæ.

BLATTOIDS INCERTÆ SEDIS.

Remains of Blattoids have been found at four horizons and in four localities in the Kent Coalfield. They were obtained from small cores, the edges of which had cut through the wings, and rendered them so fragmentary as to be useless for the determination of genera or species. They serve, however, to indicate that the Kent Coal Measures may eventually prove to be as rich in fossil insect-remains as the Coal Measures of the Pas-de-Calais. The depths of the cores given with the original description of these fossils were found afterwards to have been reckoned from a private datum, while the depths now given have been corrected to Ordnance datum.

Phyloblatta (?), sp. Plate VIII, fig. 4.

1912. *Phylloblatta* (?), sp., Bolton, Quart. Journ. Geol. Soc., vol. lxviii, p. 321, pl. xxxiii, figs. 3, 4, 5.
1915. *Phylloblatta* (?), sp., Bolton, Trans. Inst Min. Eng., vol. xlix, p. 45.

Specimen.—Impression of a Blattoid wing, 5 mm. long and 2·5 mm. wide; Museum of the Kent Coal Concessions Company, Dover.

The impression is that of the middle part of the margin of a tegmen. This may be a part of the outer margin, as I formerly supposed, but I now think it more likely to belong to the inner margin, and to show branches of the median and cubitus veins.

Horizon and Locality.—Shales at a depth of 1967 ft. in the Maydensole boring, Kent Coalfield.

Phyloblatta (?), sp.

1912. *Phylloblatta* (?), sp., Bolton, Quart. Journ. Geol. Soc., vol. lxviii, p. 321, pl. xxxiii, figs. 8, 9.
1915. *Phylloblatta* (?), sp., Bolton, Trans. Inst. Min. Eng., vol. xlix, p. 45.

Specimen.—Impression of part of a Blattoid wing, 6 mm. long and 3 mm. wide; Museum of the Kent Coal Concessions Company, Dover.

The fragment appears to belong to the proximal part of the wing, and shows a long vein giving off six branches.

Lying more inward are the remains of a short forked vein.

Horizon and Locality.—Shales at a depth of 954 feet in the Ripple boring, Kent Coalfield.

Blattoid Wing-Fragment. Plate VIII, fig. 5.

1912. "Blattoid," Bolton, Quart. Journ. Geol. Soc., vol. lxviii, p. 321, pl. xxxiii, figs. 6, 7.
1915. "Blattoid," Bolton, Trans. Inst. Min. Eng., vol. xlix, p. 45.

Specimen.—Impression of a wing-fragment 3 mm. long and 2·25 mm. wide; Museum of the Kent Coal Concessions Company, Dover.

The fragment shows a little of a well-curved margin and three veins, one with a small fork on the wing-margin. The curvature indicates that the fragment belongs to the apical end of the wing.

Horizon and Locality.—Black shale at a depth of 2180 feet in the Barfreston boring, Kent Coalfield.

Blattoid Wing-Fragment. Plate VIII, fig. 6.

1915. "Blattoid," Bolton, Trans. Inst. Min. Eng., vol. xlix. pp. 45, 46, pl. ix, fig. 24.

Specimen.—Distal portion of a tegmen, including the whole of the wing-apex; Museum of the Kent Coal Concessions Company, Dover.

Portions of the subcosta, radius, and median veins can be determined. The subcosta is represented by a little of the main stem which sends off four simple branches to the outer margin. The radius divides low down into two branches, the outer dividing again into two nearly equal twigs, which pass out to the outer margin of the wing. The inner branch divides into four twigs, all reaching the apical margin. The cubitus is represented by a long vein, giving off a series of eight to nine inward branches.

Horizon and Locality.—Shales at a depth of 2424 feet in the Stonehall boring, Kent Coalfield.

Family Mylacridæ, Scudder.

1879. Scudder, Mem. Bost. Soc. Nat. Hist., vol. iii, pt. 1, no. 3, p. 40.
1906. Handlirsch, Die Fossilen Insekten, p. 258.

Fore-wings variable in shape, but generally broad and short, nearly always widest at the base. Costal area more or less triangular. Subcosta with branches arising in a radial manner. Radius sending numerous branches outwardly, or dividing into two widely dividing branches. The median either gives off its branches serially, or forms two compound main branches. Cubitus with a variable number of inward branches. Anal area large, with the anal veins usually ending on the inner margin (Handlirsch).

Scudder established this family for a numerous series of North American Blattoids, all of which are characterised by the subcostal area being widened out basally, and the subcostal vein and its branches reduced from the strap-shaped form seen in Archimylacrids to a shorter structure, in which the branches arise mainly from the root of the vein, and radiate in fan-fashion into the subcostal area.

The humeral portion of the subcostal area is usually smooth, and destitute of subcostal branches, or where these are present, they are short and do not reach the margin. Owing to the enlargement of the subcostal area, the point of attachment

of the wing becomes central, instead of being in front of the wing-axis as in the Archimylacridæ. The principal veins and their branches show a greater tendency to pass straight outwards to the wing-margin than in the Archimylacridæ, while the pronotum has become broader and shorter, and assumes more of a reniform appearance.

The wing-surface is leathery and coriaceous, and often cross-wrinkled. Pruvost states that the interstitial neuration is composed of a fine network of nervures, which is more correct, the thickened wrinkled condition being a later development. The body is broad and flat.

Handlirsch regards the Mylacridæ as an early, extremely developed, lateral branch of the Blattoid series, and thus still retaining rather primitive characters, best seen in the median vein. Handlirsch adds (1906, 'Proc. U.S. Nat. Mus.,' vol. xxix, p. 766): "Perhaps they owe their origin to an adaptation to their environment, for it is remarkable how similar many of them are to certain leaves of ferns, with which they are generally found (a fact to which Scudder had already drawn attention). Probably they lived under deciduous fern-fronds, and by their similarity to the pinnæ were protected from their enemies."

Pruvost (1920) considers that the Mylacridæ may constitute a well individualised phyletic series which sprang late from the Archimylacrid stock. He divides the family Mylacridæ into two divisions, Hemimylacridian and Mylacridian, the former, as typified in *Phylomylacris* and *Hemimylacris*, being really intermediate forms lying between the true Archimylacrids and the true Mylacrids (Mylacridians), and more nearly descended from the first. Pruvost also points out that Handlirsch has placed *Apophthegma* (the *Hemimylacris* of Saxony) with the Archimylacridæ, and the American members of the *Hemimylacris* among the Mylacridæ. He is somewhat uncertain whether to place the Hemimylacridians with the Archimylacridæ or with the Mylacridæ, but decides in favour of the latter, suggesting that both the Hemimylacridians and the Mylacridians are of polyphyletic origin.

Genus **HEMIMYLACRIS**, Handlirsch.

1906. *Hemimylacris*, Handlirsch, Proc. U.S. Nat. Mus., vol. xxix, p. 767.

Generic Characters.—Wings twice as long as wide. Costal area broad, in one species almost triangular, in another somewhat strap-shaped. Radius with four outer branches, the first dividing into two or three twigs. Median with three branches directed inwards. Cubitus with 4—5 branches which do not occupy the whole of the free inner margin. Anal area two-fifths the length of the wing, and more than twice as long as wide.

Handlirsch remarks that this genus may be classed almost as well with the Archimylacridæ as with the Mylacridæ, thus agreeing with Pruvost.

Hemimylacris obtusa, Bolton. Plate VIII, fig. 7; Text-figure 38.

1911. *Hemimylacris obtusa*, Bolton, Quart. Journ. Geol. Soc., vol. lxvii, p. 154, pl. x, figs. 4, 5.

Type.—A stout right tegmen, lying on a surface of fireclay full of Stigmarian rootlets, and distorted by pressure; Museum of Practical Geology, Jermyn Street (no. 24510).

Horizon and Locality.—Upper Coal Measures (Four-foot Seam of Swansea); Gladys Colliery, one mile east-south-east of Penller-gaer Church, Glam.

Specific Characters.—Costal margin convex; subcostal vein dividing by repeated forking into five twigs; costal area triangular. Radius with a radial sector, the latter much divided. Median with a few forked inward branches. Cubitus large, with four branches, the second twice forked. Anal area wide, and crossed by numerous veins, the first giving off a simple branch, and then dividing twice by equal forking. Inner margin almost straight.

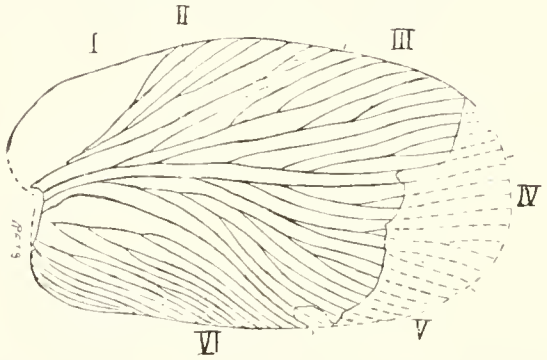


Fig. 38.—*Hemimylacris obtusa*, Bolton; diagram of right fore-wing with apex restored, three times natural size.—Upper Coal Measures (four-foot Seam of Swansea); Gladys Colliery, near Penller-gaer Church, Glamorganshire. Mus. Pract. Geol. (no 24510). Numbering of veins as in Text-figure 33, p. 104.

Description.—A short rounded right tegmen, 23 mm. long and 14 mm. wide, broken across the basal third along the anal furrow, and the apex missing.

The subcostal area is broadly triangular, the subcostal vein sunken, and passing out obliquely, giving off a basal branch which forks into two equal twigs, the most distal twig forking again. A single undivided branch is given off near the end of the subcosta.

The radius gives off a strong radial sector, and afterwards sends outwardly three simple branches. The radial sector sends four branches to the margin, the first forking twice, and the fourth once, the second and third being simple.

The median vein appears to give off the stem of the cubitus near its base, but this appearance is probably due to the crumpling of the tegmen. The first of the three inward branches of the median arises further out than any of the divisions of the radius or cubitus. The first branch divides into three twigs, and the second forks on the broken edge of the wing. All the branches pass straight out towards the wing-apex.

The cubitus is convex in its basal half, and straightens out distally, giving off four inward branches, the second dividing into three, and the fourth forking. The divisions of the cubitus occupy the distal half of the inner margin.

The anal area is large, and marked off from the rest of the wing by a deep anal furrow. The first anal vein breaks up into five divisions, by a triple forking, and the second forks twice. The third anal vein forks near its base, and the remaining 3—4 veins appear simple. The anal veins end on the margin in at least fourteen twigs.

The interstitial neuration cannot be determined.

Affinities.—The mode of branching of the subcostal vein, the presence of a decided radial sector and the character of the first anal vein, are features which would justify the inclusion of this species in the genus *Soomylacris*, were it not for the fact that the median is not divided into two equal branches. There is a close correspondence between this species and *H. ramificata*, Handl., and I therefore retain it in the genus *Hemimylacris*, although, as I have stated elsewhere, I am inclined to merge the two genera into one, as marking a transitional group between the Archimylacridæ and the Mylacridæ.

Hemimylacris convexa, Bolton. Plate VIII, fig. 8.

1911. *Hemimylacris convexa*, Bolton, Quart. Journ. Geol. Soc., vol. lxvii, p. 156, pl. vii, fig. 3.

Type.—Proximal half of a tegmen lying on an irregular surface of black shale; Museum of Practical Geology, Jermyn Street (no. 24512).

Horizon and Locality.—Pennant Series (Shales associated with the Graigola Seam); Clydach Merthyr Colliery, Clydach Valley (Swansea Vale), Glam.

Specific Characters.—Costal area triangular. Radius with a well-defined radial sector, the two occupying most of the outer margin and the outer half of the wing-apex. Median small. Cubitus arcuated and ending on the middle of the inner margin, and outer third of the apex. Anal veins few.

Description.—Only the proximal half of the tegmen is shown, and this does not exceed 10 mm. in length. The subcostal area is much crushed and broken, and but two branches of the subcostal vein can be seen on it.

The radius arises in the middle of the base, and at once divides, evidently giving off a radial sector. The radius shows two marginal veins, while the radial sector sends off a long branch towards the wing-apex, the branch forking near the broken edge of the wing.

The median vein is represented by a portion of the main stem, which forks twice.

The cubitus has an arcuated stem bifurcating twice into four branches. Three anal veins can be distinguished.

Affinities.—The fragmentary and crumpled condition of this wing makes its elucidation difficult and unsatisfactory. The chief features distinguishable are the almost equal costal and anal areas, the presence of a radial sector, and the origin of several anal veins arising from one stem. Few though these characters be, they are sufficient to refer the specimen to the Mylaeridæ, and to the genus *Hemimylacris*.

Genus **PHYLOMYLACRIS**, Pruvost.

1919. *Phylomylacris*, Pruvost, Faune Continent. Terr. Houill. N. France (Mém. Explic. Carte Géol. France), p. 199.

Generic Characters.—Tegmina semi-ovate, with rounded apex. Surface coriaceous, with a fine close meshwork of interstitial nervures giving a shagreen-like appearance. Wing-attachment in middle of wing. Costal area triangular. Subcostal branching, partly pectinated and partly radial, extending beyond the middle of the wing. Radius well developed. Median with numerous branches. Cubitus large and well branched. Anal area large, convex, and crossed by numerous anal veins.

Pruvost has formed this genus to include certain Blattoids found in recent years at Lens and Liévin in northern France. They possess a superficial resemblance to the type-species of *Necymylacris*, *N. heros*, Scd., but their differences are nevertheless so marked as to justify the formation of a new genus. Pruvost in the work in question placed Goldenberg's *Blattidium mantidioides* in the genus *Archæotiphe*, having at the time only the original drawings of Kirkby to rely on. After borrowing the type-specimen, I came to the conclusion that Goldenberg's species must be referred to a new genus, in which I also placed *Necymylacris villeti*, Pruv., *N. lafittei*, Pruv., and *N. godoni*, Pruv. To this new genus I proposed to attach the name of my French friend, Dr. P. Pruvost, and intimated my intention to him, at the same time sending my manuscript. I received a reply and the proof-sheets of his new work, in which it appeared that he also had recognised that the three species previously referred to *Necymylacris* must be placed in a new genus, to which he had already given the name of *Phylomylacris*. Our conclusions were identical as to the generic value of his species, and as his work antedates my own, I am unable to attach his name to the new genus, but must adopt the generic name of *Phylomylacris* for the British species.

Had Dr. Pruvost received my photographs and drawings earlier, he would not have referred *B. mantidioides* to the genus *Archæotiphe*, but to *Phylomylacris*, as he based the characters of the latter on the same details of structure as I had determined for the genus in which *B. mantidioides* should be placed. The fact that we arrived at the same conclusion, and by the selection of the same structures, has been a satisfaction to both.

Phylomylacris mantidioides (Goldenberg). Plate IX, fig. 1; Text-figure 39.

1867. *Blatta* or *Blattina*, Kirkby, Geol. Mag., vol. iv, p. 388, pl. xvii, figs. 6, 7.
1877. *Blattidium mantidioides*, Goldenberg, Fauna Saræpont. Foss., vol. ii, p. 20.
1879. *Etoblattina mantidioides*, Scudder, Mem. Bost. Soc. Nat. Hist., vol. iii, p. 72, pl. iii, fig. 6.
1906. (*Archimylacridæ*) *mantidioides*, Handlirsch, Die Fossilen Insekten, p. 237, pl. xxiv, fig. 27.
1919. *Archæotiphe mantidioides*, Pruvost, Faune Continent. Terr. Houill. N. France, p. 170.

Type.—Basal half of left tegmen in nodule; Kirkby Collection, Hancock Museum, Newcastle-on-Tyne.

Horizon and Locality.—Upper Coal Measures (zone of *Anthracomya phillipsii*); South Hylton, opposite Claxheugh on the Wear, Durham.

Specific Characters.—Surface of wing coriaceous. Costal margin convex; subcosta feeble, with few simple branches passing obliquely to the margin. Costal area acutely pyriform. Radius much divided, and occupying outer half of wing-apex Median with numerous divisions, and passing to inner half of wing-apex.

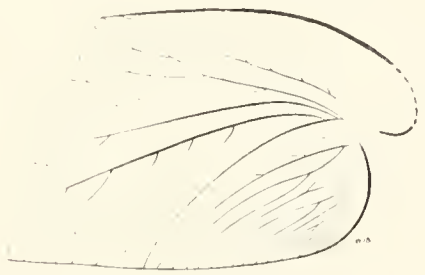


Fig. 39.—*Phylomylacris mantidioides* (Goldenberg); diagram of venation of type, a left fore-wing, three-and-a-half times natural size.—Upper Coal Measures (zone of *Anthracomya phillipsii*); South Hylton, opposite Claxheugh on the Wear, Durham. Hancock Mus., Newcastle-on-Tyne (Kirkby Coll.).

Cubitus large, extending to the distal end of the inner margin, and giving off five or more inner branches, the first and third dividing. Anal area tumid, anal furrow well defined. Anal veins 9—10 in number, the first forking twice, and also sending three weak branches forward. Inner margin convex, but less so than costal margin.

Description.—The surface of the nodule surrounding the wing-fragment is covered with the "spat" or young fry of a species of mollusc to which Kirkby gave the name of *Ancylus vinti*, but which I have since shown to be the young fry of *Anthracomya phillipsii* ('Trans. Inst. Mining Engin.,' vol. xlix, p. 675, 1915); also Trechmann and Woolacott ('Geol. Mag.' [6], vol. vi, p. 207, 1919).

The wing-fragment, measuring 13·5 mm. long and 8 mm. wide, is in excellent condition, and lies with the dorsal surface uppermost. The whole of the venation is well marked. Kirkby's original figure is not correct, and his errors have been repeated by Scudder and Goldenberg. Goldenberg did not describe the species he named, and Scudder, to whom we owe the first detailed account, was hindered by the faulty drawing, and does not seem to have seen the specimen. Handlirsch removed the species from *Etoblattina*, regarding the specimen as an indeterminable

form of the Archimylacridæ. Re-examination of the type-specimen shows errors in the earlier descriptions and figure, and I now re-describe and re-figure the type, placing it in the new genus established by Pruvost.

The wing is a stout structure, with a coriaceous surface which has enabled it to be perfectly preserved. The costal margin is well rounded inwardly at the base, and flattens over the middle of the wing. Assuming that it agreed with wings of a Phylomylacrid type, the margin would gradually merge distally into a broadly rounded apex.

The subcostal vein is the weakest of the whole series, and passes obliquely outwards, reaching the margin about the middle of the wing. It gives off five undivided branches which are oblique in direction, and fail to reach the margin.

The costal area is broad basally, and ends in an acute angle against the margin. It may be best described as pyriform.

The radius is a powerful vein, giving origin, in the inner third of the wing, to what seems to be a well-marked radial sector, and dividing into two equal branches a little further out. The outer of the two distal branches divides by twice forking into three twigs, which may have reached the middle of the outer margin. The inner of the two branches forks once only.

A wide area separates the radius from the subcosta over the greater part of its length, the widest interval being at the point where the radius divides into two main branches. The branch (? radial sector), of which but few divisions are shown on the wing-fragment, diverges inwardly from the main stem of the radius into the middle of the wing, giving off two branches, the first forking close to the broken edge of the nodule. From its position the ultimate divisions must have ended upon the outer half of the wing-apex, and the distal part of the outer wing-margin.

The various divisions of the radius are so divergent that they enclose a considerable portion of the whole wing, while they are equally well spaced out from the subcosta in front, and the median behind. The base of the radius stands up in relief, and owing to a little enfolding of the wing, overhangs the bases of the median and cubitus, but does not unite with them.

The median vein arises close to the radius, and like the latter, bends inwards at the base in a strong curve, which is continued until the direction is obliquely inward, when it becomes straightened.

At the summit of the basal curve the median sends off a short oblique vein inwards to the cubitus. This vein is a distinct commissure, and not an enlarged interstitial nervure. The significance of this commissural vein is not yet fully understood. Pruvost has recorded a similar structure in species of the genus *Archimylacris* (*op. cit.*, p. 151), and mentions that Scudder and Handlirsch have also indicated its occurrence in other forms. It is not, however, present in *Archimylacris woodwardi*, Bolton, and *A. hastata*, Bolton.

The median remains undivided in the proximal third of the wing, and then forks, the inner of the resultant veins again dividing on the broken edge. The areas on either side of the main stem of the median are, like those of the radius, well spaced.

The cubitus vein is less curved basally than the median and radius, well separated from the latter, and passing obliquely towards the distal end of the inner margin of the wing. It gives off six inward branches, the first arising near the base, and margins the anal furrow. The second branch gives off two irregular twigs which do not reach the margin, and the fourth is forked. The rest are undivided.

The whole of the anal area is remarkably well developed. It stands out as a tumid mass, marked off from the rest of the wing by the first branch of the cubitus, and with all the anal veins in high relief.

A broad area interposes between the first anal vein and the anal furrow, and upon this run out a few small and wavy veins which die out on the membrane. The first well-defined vein has a short stem dividing at once into two equal branches, which continue to the margin. The inner of these two branches either forks again, or has received the larger and distal portion of the next vein, the basal part being joined to the third vein, and forming an enclosed area. The next vein forks, and also the sixth, the remainder being closely packed together, and rapidly diminishing in strength and length as they crowd down upon the margin.

The interstitial neuration consists of a well-defined meshwork which shows a tendency to a longitudinal arrangement in the direction of the wing-margin.

Affinities.—The incorrect figure published by Kirkby has been a source of confusion, and probably accounts for Goldenberg's reference of the species to *Blattidium*, Scudder. At the time when he so referred it, Scudder had become familiar with the distinctive characters of wings of this type, and had created a new genus *Necymylacris* to receive them ('Mem. Boston Soc. Nat. Hist.,' vol. iii, p. 52, 1879). We can only account therefore for his reference of the wing to *Etoblattina* on the score of the faulty drawing, as he does not seem to have seen the wing. The later drawing by Handlirsch is wrong in almost every detail, and his reference of the wing to the Archimylacridæ was the only one possible under the circumstances.

Scudder's genus *Necymylacris* was founded, not upon *N. lacoana*, as Handlirsch assumes (a fragment only of that wing being known), but upon *N. heros*. Handlirsch's later name of *Eumorphoblatta* ('Die Fossilen Insekten,' p. 195, 1906) is rightly reduced by Pruvost ('Ann. Soc. Géol. Nord,' vol. xli, p. 350, 1912) to the position of a synonym.

The figures of the three new species published by Pruvost in that paper are admirably reproduced, and as they show a complex of raised nervures in nearly

all the areas of the wings, such as is seen in the British specimen, and as the species agree among themselves while differing from the type of Scudder's genus *Neeymylacris*, I considered them to represent a new genus, as already mentioned. In *N. heros* Scudder plainly shows an interstitial neuration of closely-packed transverse nervures, which he describes as "a minute tracery of nearly straight, very closely approximated, excessively delicate, scarcely impressed, cross-lines."

Apart from this difference, there is a close relationship between *Neeymylacris* and Pruvost's *Phylomylacris*. Regarding, as I do, the character of the interstitial neuration, especially when well developed, as one of more than specific importance, I consider that *Phylomylacris* is a valid genus.

Genus **SOOMYLACRIS**, Handlirsch.

1906. *Soomylacris*, Handlirsch, Die Fossilen Insekten, p. 260.

Generic Characters.—Wings short and wide, being two to two-and-a-half times as long as wide. Costal area broadly triangular, the subdivisions of the subcosta arising from a central point, the inner branches only reaching the costal margin after a very oblique course. Radius with distinct radial sector. Median dividing low down into two main branches, while the cubitus is long, with simple or forked branches. Anal area large, nearly as long as the subcostal area, strongly convex, and crossed by numerous anal veins, the first usually thrice divided, both the subcostal and anal areas extending nearly to the middle of the wing.

Soomylacris deanensis (Scudder). Plate IX, fig. 2; Text-figure 40.

1895. *Etoblattina deanensis*, Scudder (in part), Bull. U.S. Geol. Surv., no. 124, p. 34, pl. xii, fig. 1.
1896. *Etoblattina deanensis*, Scudder, Geol. Mag. [4], vol. iii, p. 12, fig. 1.
1906. *Soomylacris deanensis*, Handlirsch, Die Fossilen Insekten, p. 260, pl. xxvii, fig. 15.

Type.—Right tegmen, lower view, lacking apical portion; U.S. National Museum, Washington (Lacoe Collection, no. II. 2132*b*; Nat. Mus. no. 38090).

Horizon and Locality.—Coal Measures; Foxe's Bridge, Forest of Dean, Gloucestershire.

Description.—Scudder described and figured two specimens from the Forest of Dean under the name of *Etoblattina deanensis*, but the second is dealt with in this monograph under the new specific name of *Soomylacris stocki* (see p. 130).

The type tegmen of *S. deanensis* has a length of 25 mm., and a maximum breadth of 13 mm. across the anal area. Scudder gives the length as 38 mm., but the wing has lost a second portion of the apical end since he figured the specimen. The anal area is broken, and has become slightly displaced along the line of the anal furrow, but to so slight an extent as not to hinder measurement.

The costal margin is strongly convex basally, becoming almost straight over the middle of the wing, in this respect differing from *S. stockii*, which is increasingly convex in the middle of the wing—a fact noted by Scudder. The inner margin is more nearly straight, and the wing narrows as the apex is reached, the maximum width being across the anal area.

The subcosta is made up of three main branches, the first forking into two equal twigs, the second forking twice into three twigs, and the third forking three times into four twigs. The subcostal area is very wide basally, and terminates in an acuminate angle beyond the junction of the first and second thirds of the wing.

The radius is a powerful vein dividing low down into two main branches, the outer breaking up into four twigs by a trifid forking, while the inner branch forks into two, and each of these into two again, the two twigs of the inner secondary fork each dividing into two. The radius thus ends on the broken edge of the wing in ten twigs.

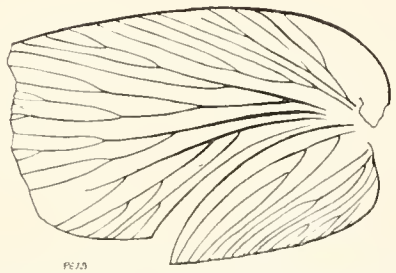


FIG. 40.—*Soomylacris deanensis* (Scudder); diagram of venation of right tegmen (the diagram reversed), twice natural size.—Coal Measures; Foxe's Bridge, Forest of Dean, Glos. U.S. National Museum, Washington (Lacoe Coll., no. H. 2132*b*; Nat. Mus. no. 38090).

The median vein forks into two main branches at about the end of the proximal third of the wing. The outer branch divides into two equal twigs, the inner forking again further out. The inner branch forks once only on that portion of the wing which is now preserved, although Scudder has figured it as breaking up into six ultimate twigs by repeated forking of the innermost of the two branches now seen. Scudder shows twelve twigs of the median ending on the inner half of the wing-apex, while the actual specimen now shows only five. Scudder is wrong in showing a twig coming off inwardly from the first main division of the median, and dying out in the wing-membrane. The appearance is due to a slight furrow on the impression. This furrow can be traced across the branches of the adjoining cubitus.

The cubitus, like the median, is sigmoidally curved, and gives off five inward branches, and ends upon the distal end of the inner margin in a small fork. The second and third branches of the cubitus fork twice, and end on the margin in three twigs each.

Unlike the rest of the wing, which is flatly convex, the anal area is well rounded, and must have projected somewhat above the general surface. It is

crossed by six anal veins, the first being a large structure breaking up into four branches, and more widely separated from the anal furrow proximally than is its outer branch distally. The second vein is simple. The third forks twice, and ends in three twigs. The fourth and fifth fork once each. Traces of two more anal veins are seen on the margin.

The interstitial neuration can only be distinguished clearly in the anal area, and consists of irregular cross-nervures which cross the main veins and unite laterally to form a meshwork, which is not, however, of a strictly reticulate character.

Soomylacris stocki, sp. nov. Plate IX, fig. 3; Text-figure 41.

1895. *Etoblattina deanensis*, Scudder (in part), Bull. U.S. Geol. Surv., no. 124, p. 34, pl. xii, fig. 3.
1896. *Etoblattina deanensis*, Scudder, Geol. Mag. [4], vol. iii, p. 12, fig. 2.
1906. *Soomylacris deanensis*, Handlirsch, Die Fossilen Insekten, p. 260, pl. xxvii, fig. 16.

Horizon and Locality.—Coal Measures; Crump Meadow, Forest of Dean, Gloucestershire.

Type.—Fragments of two tegmina; U.S. National Museum, Washington (Lacoe Collection, no. H. 2132 *c*; Nat. Mus. no. 38090).

Description.—The fragment of a left tegmen has lost much of its base and apex, while the greater part of the anal area is obscured by the anal area of the presumably opposite right tegmen. It lies with the under-surface uppermost, the anal area of the second tegmen being right side uppermost. Feeble traces of what appear to be a hind-wing can be distinguished through the fragment of tegmen, and project a little beyond its margin at one point. The specimens are on a dark grey shale in which occur numerous remains of *Neuropteris*, *Annularia*, etc.

The outer margin is seen on the displaced shoulder of the wing, and on the portion of the outer half of the wing that remains. It is more convex than in *S. deanensis*, and the shoulder bends inwards almost at a right-angle, that of *S. deanensis* being regularly rounded.

The subcosta is represented by the bases of three stout veins which spring from the same point, all showing forking, and by two straight veins running out on the costal margin on the fragment. These two seem to be the terminals of the innermost forking seen on the shoulder of the wing. The intercostal area is broader than that of *S. deanensis*. The base of the radius is missing, and the union of the two twigs into which the outer branch divides is missing. Each of these twigs forks again half-way between its origin and the margin.

The inner branch of the radius divides by twice forking, and the inner of the resultant twigs forks again, so that the radius ends on the margin in at least nine twigs.

The median forks equally twice, the inner of the four twigs again forking twice into three.

The cubitus is a simpler structure than that of *S. deanensis*. It consists of a sigmoidally curved main stem giving off five inward branches, the first and third only forking. The cubitus, therefore, ends on the inner margin in eight twigs, that of *S. deanensis* in eleven.

The anal area of the right tegmen is superficially much like that of *S. deanensis*, but the first anal vein gives off three branches in place of two, the innermost forking. In *S. deanensis* the middle branch forks. The second vein forks twice, that of *S. deanensis* being undivided; the third forks once into two twigs, that of *S. deanensis* having three; the fourth forks once, the fifth is undivided, and the sixth forks twice into three twigs. Traces of a seventh vein are present. Portions of the anal area are shown near the inner margin, and above the outer edge of the anal area of the right wing, but they are too fragmentary to determine the course of the veins.

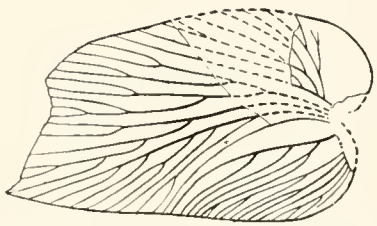


FIG. 41.—*Soomylacris stocki*, sp. nov.; diagram of venation of two tegmina, twice natural size.—Coal Measures; Crump Meadow, Forest of Dean, Glos. U.S. National Museum, Washington (Lacoe Coll., no. H. 2132*c*; Nat. Mus. no. 38090).

The inner margin is almost straight, and owing to the greater convexity of the outer margin, the wing appears to have been narrower apically than *S. deanensis*.

The interstitial neuration is similar to that of *S. deanensis*. Traces of possibly one of the hind-wings can be seen underneath the costal margin and under the outer twigs of the radius. The wing is closely related to that of *S. deanensis*, but the differences, especially in the cubitus, are sufficient to distinguish the two.

Soomylacris burri, Bolton. Plate IX, fig. 4; Text-figure 42.

1912. *Soomylacris* (*Etoblattina*) *burri*, Bolton, Quart. Journ. Geol. Soc., vol. lxviii, p. 318, pl. xxxiii, figs. 1, 2.

Type.—Left tegmen; Museum of the Kent Coal Concessions Co., Dover.

Horizon and Locality.—Coal Measures (dark shale from a depth of 1208 feet); Barfreston Boring, Kent.

Specific Characters.—Subcosta with few divisions. Radius with well-marked radial sector, which is well developed and much divided. Median with two main

divisions. Cubitus large, with six simple branches. Anal area very wide basally, and with 4—6 veins. Tegmen tapering along both margins to the apex.

Description.—The tegmen lies with the under surface uppermost, lacking only a small portion of the wing-apex. It is short and broad, measuring 14 mm. long and 8 mm. wide. The dorsal surface is convex, the exposed under surface being concave.

The costal margin is rounded, especially in the basal portion of the subcostal area. Distally the margin curves into the wing-apex, which is bluntly rounded. The inner margin curves outwards in its distal half, so that the wing is widest basally, and narrows into the wing-apex.

The subcosta is a strong vein with few branches, the first two being simple, and passing out obliquely. A forked branch arises further out, and near the margin of the wing a single simple branch. The costal area is broad basally, and well rounded.

The radius is a large, much-divided vein, occupying, with the subcosta, the outer half of the wing. It is short, and gives off a radial sector in the basal

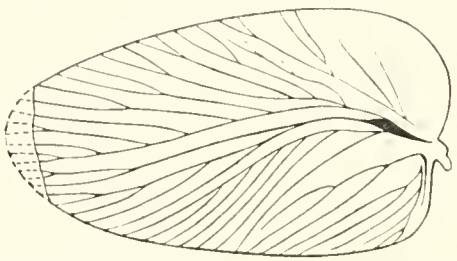


FIG. 42.—*Soomylacris burri*, Bolton; diagram of venation of left tegmen, four times natural size.—Coal Measures (dark shale from a depth of 1208 ft.); Barfreston Boring, Kent. Mus. Kent Coal Concessions Co., Dover.

fourth, afterwards passing out obliquely to the outer margin, and giving off four outward branches, the first irregular in its course, and with two feeble twigs which do not reach the margin, the second and third forking well out, and the fourth small and undivided. The radial sector passes straight to the wing-apex, giving off six strong branches, the first, second, and fourth forking, the rest remaining undivided.

The median is convexly curved basally, and bent inwards to the inner margin. It gives off a strong forward triple-divided branch in the basal fourth, and further out a second branch, which forks three times into four branches. The eight divisions of the median end on the distal third of the inner margin and part of the apex.

The cubitus describes a regular sigmoidal curve, and gives off at regular intervals a series of six inwardly directed branches, all of which are undivided.

The anal area is very wide basally, and crossed by 4—6 veins, the first forking twice, the second once, the third undivided, and the fourth forked. Traces of two

very small anal veins are also seen in the curve of the wing-margin. The anal area is strongly convex between the anal furrow and the first anal vein.

The interstitial neuration of the anal area appears to consist of straight cross-nervures. Over the rest of the wing the interstitial neuration cannot be made out.

Affinities.—When first describing this species, I regarded it as closely allied to forms which Handlirsch has placed in his genus *Hemimylacris*. There can be no doubt, from what has been already said, that a close relationship exists. Pruvost (*op. cit.*, pp. 222—4) has recorded two species of *Soomylacris* from the Lens and Liévin Coalfields of Northern France, *S. liévinensis*, Pruv., and *S.* aff. *deanensis*. The occurrence of these British species may serve to indicate the Westphalian affinities of the Kent and Forest of Dean Coalfields.

Genus **ORTHOMYLACRIS**, Handlirsch.

1906. *Orthomylacris*, Handlirsch, Proc. U.S. Nat. Mus., vol. xxix, p. 768.

Generic Characters.—Tegmina two to two-and-a-half times as long as wide, with a sub-cordate outline. Costal area extending from one-half to two-thirds the length of the tegmen. Radius extending to the tegmen-apex, and giving off a large number of outward branches. Median with few veins, directed towards the apex and the inner margin. Cubitus never reaching the apical margin, and with few branches. Anal area at least twice as long as high. Structure leathery, and with cross-wrinkles.

Orthomylacris lanceolata, Bolton. Plate IX, fig. 5; Text-figure 43.

1911. *Orthomylacris lanceolata*, Bolton, Quart. Journ. Geol. Soc., vol. lxvii, p. 167, pl. x, figs. 1, 2.

Type.—Left tegmen; Museum of Practical Geology, Jermyn Street (no. 24511).

Horizon and Locality.—Coal Measures (shales associated with the Graigola Seam, Pennant Series); Clydach Merthyr Colliery, Clydach Valley, Swansea Vale, Glam.

Specific Characters.—Tegmen long, and uniformly tapering to the apex. Upper surface regularly convex. Subcostal area broadly triangular, with oblique branches. Radius much branched. Median unbranched in basal half, with three outer branches. Cubitus divided into two main branches, the outer forking into two equal twigs, and the inner giving off three inward twigs, the first only forking. Outer and inner margins convex.

Description.—The tegmen, which measures 23 mm. long and 10 mm. wide, lies with the dorsal surface uppermost, and is gently rounded along its length, a slight flattening only being visible over the middle of the outer margin. The uniform tapering of the two margins to the apex produces an elongate form of tegmen of an unusual type among Blattoids. The base of the tegmen is lost, and the costal area appears therefore to occupy nearly half the outer margin.

The subcosta is thin, sunk in the tegminal structure, and gives off three forked branches which pass in straight oblique lines to the margin.

The radius is a large vein, with four branches, the first three doubly-forked and the last undivided. The main stem of the radius is convex in the basal part of its length, and concave in the outer half. The branches pass out very obliquely and extend on to the apical margin.

The median divides about the middle of the tegmen, on a level with the third branch of the radius. It gives off three branches, the first forking twice into four equal twigs, the second of the series forking again near the margin. The inner pair of twigs unite in the middle of their length, and separate again further out, so that a lenticular "cell" is produced. The second branch is undivided. The third branch divides into a long outer twig which bends forwards towards the apex, and a smaller and weaker twig which goes straight out to the inner margin. There is, as a result of this separation, a wide part of the inner margin destitute of veins.

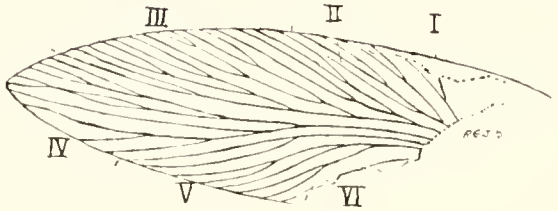


Fig. 43.—*Orthomylacris lanceolata*, Bolton; diagram of venation of left tegmen, three times natural size.- Coal Measures (shales associated with the Graigola Seam, Pennant Series); Clydach Merthyr Colliery, Clydach Valley, Swansea Vale, Glam. Mus. Pract. Geol. (no. 24511). Numbering of veins as in Text-figure 33, p. 104.

The cubitus arises close to the median, and at once divides into two main branches, the outer being forked once only, and the inner giving off a forked branch succeeded by two which are undivided.

The anal area has broken away along the line of the anal furrow. It is shorter than the subcostal area.

The interstitial neuration cannot be determined with certainty. The surface near the apex is marked by cross-wrinkles, but I cannot affirm that this is a part of the neuration.

LARVAL BLATTOIDS.

(Blattoidea) peachi (Woodward). Plate IX, fig. 6.

1887. *Etoblattina peachii*, Woodward, Geol. Mag. [3], vol. iv, p. 433, pl. xii, fig. 1.
1906. (*Blattoidea*) *peachii*, Handlirsch, Die Fossilen Insekten, p. 178, pl. xviii, fig. 26.

Type.—Upper surface of head, pronotum, rudimentary wings, and broad segmented abdomen, in nodule of fine grey sandstone; Kilmarnock Museum.

Horizon and Locality.—Coal Measures ("grey sandy shale with nodules of impure clay and ironstone" at 91 ft. 6 in. below the surface); Greenhill Pit, Kilmarnock.

Description.—The length of the insect is 23 mm. and its width across the fore-wings 15 mm. The pronotum is 12 mm. wide, and 5 mm. long. The abdomen is 12 mm. long and diminishes in width from before backwards. The coarse character of the stone has obliterated or failed to preserve all the finer detail of the specimen, but the insect still retains the gently convex dorsal surface which it doubtless had during life.

The very small head, not well defined, is apparently divided into two small anterior and two larger posterior areas by shallow longitudinal and transverse grooves. No appendages are visible. A raised V-shaped portion of the matrix in front of the head may indicate that it formerly extended beyond the line of the pronotum. The two anterior plates covering the head are notched in a small V on the middle outer edge.

The pronotum is nearly two-and-a-half times as wide as long, with rounded latero-posterior angles and almost straight posterior border. The front border forms a semicircle, recessed in the middle, and enclosing the head-shield termed by Dr. Henry Woodward an "epicranial plate."

Two pairs of rudimentary wings are present, the first pair articulating well forward, as if attached to the mesonotum under the hinder margin of the pronotum; the hinder pair being joined to the metanotum nearer the middle line. The wings are about 10 mm. long and 5 mm. wide, with blunt apical angles. The front pair of wings have begun to take on the character of tegmina, being stouter than the inner pair.

The venation of the wings is but faintly indicated. Woodward has stated that the "mediastinal" vein and the veins of the anal and intermedian area are seen in all four wings. In present nomenclature this means that the subcosta and the cubitus are present, with some traces of the anal veins.

This seems hardly to be the case. The left hind-wing has the veins best marked, and all that can be said is, that there are indications of a few short, thick veins passing from near the attachment of the wing towards the inner margin, and crossing the middle of the wing. The condition is much like that figured by Comstock and Needham ('Amer. Nat.' [4], vol. xxxii, p. 773, fig. 56, 1898) in the hind-wing of the nymph of a cockroach, except that the veins in the Kilmarnock specimen spread fanwise, instead of keeping in close order down to the wing-apex. The veins present will therefore agree best with the radius, median and cubitus. The vein which I consider the radius is nearly parallel with the outer margin and better defined than the rest.

The length of the mesonotum and metanotum together is 6 mm. Neither is well seen owing to the overlap of the wing-bases.

The abdomen is in excellent preservation, and has several features of interest. It is 12 mm. in length, diminishing from a breadth of 10 mm. across the body and expanded epimera to 3·5 mm. across the ninth segment. The central axis of the abdomen is more convex than the lateral epimera, and the middle line is slightly ridged. The abdomen forms about one-third of the total breadth, being 4 mm. wide in the first segment, diminishing to 1·5 mm. on the ninth segment. The tenth segment is missing.

The epimera are broad, with slightly thickened posterior edges. From the posterior dorsal margins of the first to fourth segments arise thin plate-like expansions. These pass back over the succeeding two segments, showing ragged edges, as if they had a greater extension during life, and had since been partially torn away. The precise relation of these structures to the segments is not quite clear. On the right side of the first, second and third segments, these processes seem to emerge from beneath the hinder edges of the terga. If they do not, but are continuous with the hinder edge, they are yet distinct from the latter, as the suture-line between the adjacent terga can be traced outwards along the front edge of the epimera, and if the two are united this furrow may have functioned as a joint.

The undeveloped wings, scarcely wider than the pronotum, and the broad epimera of the abdomen, clearly indicate the larval condition of the specimen. It must be more advanced towards the adult stage than *Leptoblattina exilis*, Woodw., from the Coal Measures of Coseley, Staffordshire, as it differs considerably in the greater breadth of the abdomen and the development of the epimera.

In size (*Blattoidea*) *peachi* is two-thirds the length of such an adult form as *Aphthoroblattina johnsoni* (Woodw.), and as size is fairly well correlated with development in Blattoids, we may assume that the insect had not fully reached the nymph stage. This conclusion seems to be also confirmed by comparison with the wing-length of *L. exilis*, where the wings are double the length of the pronotum.

The absence of determinable details in the wings prevents any successful attempt to assign the specimen to a position in any accepted classification. The most that can be said is, that the great breadth of the pronotum, as contrasted with the length, would seem to indicate a relationship with the Mylacridæ.

Leptoblattina exilis, Woodward. Plate IX, figs. 7, 8.

1887. *Leptoblattina exilis*, Woodward, Geol. Mag. [3], vol. iv, p. 56, pl. ii, figs. 2, 3.
1906. (*Blattoidea*) *exilis*, Handlirsch, Die Fossilen Insekten, p. 173, pl. xvii, figs. 16, 17.

Type.—Nearly perfect larval blattoid in an ironstone nodule; British Museum, Johnson Collection (no. 1065).

Horizon and Locality.—Middle Coal Measures (binds between the "Brooch" and "Thick" coals); Coseley, Staffs.

Description.—The type-specimen and a second (no. 1066), described at the same time, show an almost complete pronotum, two pairs of rudimentary wings, and a long jointed abdomen. Dr. Henry Woodward recognises a portion of the head projecting in front of the pronotum in each, but of this I am doubtful. He also describes the head as follows: "The head is very small, and somewhat bluntly pyramidal in form, and measures 2 mm. in breadth at its base, where it disappears beneath the pronotum, and is 2 mm. in length. There is a suture visible down the centre which divides the two epicranial plates, at the sides of which the eyes would be seen; in front of the epicranium a small projection no doubt represents the clypeus with the labrum at its extremity."

In the type-specimen (Pl. IX, fig. 7) the pronotum, 7·5 mm. long and 9 mm. wide, is well rounded in front and on the sides, the margin of the latter passing by blunt rounded angles into an almost straight hinder border. The surface is marked out into the usual central raised area, bordered by slight grooves which deepen backwards, and curve inwards. The lateral portions are flattened.

The dorsal part of the mesonotum is partially exposed, its anterior edge being hidden beneath the pronotum. The front pair of wings is attached to the mesonotum so far forward as to touch the hinder edge of the pronotum. The surface of the mesonotum was originally rounded, and judging from its present condition, somewhat thin. It is now slightly puckered by folding.

The metanotum is similar in character to the mesonotum, but a little more robust, and has the second pair of wings still articulated near the front margin.

The abdomen is long, the segments immediately following the body being flattened by pressure, and their boundaries not clearly discernible. Behind follow at least five well-marked segments which decrease in diameter backwards. The last three show lateral epimera with the points turned backwards. Traces of what appear to be cerci follow the last segment. These seem to be curved inwards at their tips, and widely spaced, but their definition is unsatisfactory. The length of the abdomen behind the metanotum is 14 mm., and the last segment is not more than 2 mm. wide, the first of the six segments being double that diameter.

The wings are short, stout structures, those of the right side being perfect, and those of the left side incomplete. The right tegmen has a length of 11 mm., and the hind-wing a length of 10 mm. The venation, as in all larval wings, is very obscure, and can be best studied on the impression of the wings. It consists of a stout vein passing from the point of articulation of the wing outwards towards the wing-apex, and keeping close and parallel with the outer margin. From this vein a series of fine branches spreads fan-wise towards the inner margin of the wing, and seems to reach it. Woodward has recognised a mediastinal (subcostal) vein

and an anal vein. An examination of a good cast of the specimen by oblique light shows that there are a strong outer vein parallel with the outer margin, and at least two others with short, thick stems breaking up into a fan-like series of oblique veins which spread out towards the inner margin. From the researches of Messrs. Comstock and Needham (1899, 'American Naturalist' [4], vol. xxxiii, pp. 573–582, fig. 74), these veins seem recognisable as the radius, median and anal. I am unable to distinguish any detached limb such as that mentioned by Woodward.

The second example (Pl. IX, fig. 8) differs from the first in several small details. It lies on an inclined surface, and the abdomen has been dislocated and twisted over to the right, so that it is in a different plane from the rest of the insect.

The small "head" described by Woodward can be seen projecting from the middle of the frontal margin of the pronotum, which is a little broken away. It consists of a wedge-shaped structure, which narrows forwards, broad at its base and slightly swollen. It is divided into an anterior centrally placed plate of quadrangular outline, the hinder angle joining a sunken line (suture?) dividing the two basal plates, which Woodward terms "epicranial." Too little is seen of the anterior central plate for description, or for its recognition as a labrum.

The pronotum is raised in the centre and hollowed on the sides, while the hinder margin is partially broken away. It overhangs the bases of the first pair of wings. A ridge runs down the median line of the pronotum, the sides of the latter being less rotund than in the first specimen, and the whole pronotum is more sub-pyramidal in form.

The first pair of wings is still in place, and about 11 mm. in length, allowing for the basal part hidden under the hinder margin of the pronotum. The wings stand out at a low angle from the body, leaving the mesonotum and metanotum exposed. Both are partially crushed and crumpled, and the characters cannot be made out. The left wing is the better marked of the two.

The outer margin of the wing of the first pair is stout, and raised above the general level. Two stout ridges rise from the middle of the base and pass along the wing, the second ridge being the strongest, and traceable over two-thirds of the length, while the first ridge does not extend beyond the basal fourth. The first ridge occupies the place of the subcostal vein, and dies out in the direction of the outer margin, but with no evident branches. The second and larger ridge has all the appearance of a radius, is parallel with the outer margin, and can be seen to send off four branches to the middle of the wing-apex, and the inner half of it. The anal area is more slightly ridged, but with no discernible divisions.

The hind-wings have a straighter outer margin than the fore-wings, and are more membranous. Very little is seen of the left hind-wing. The outer margin of the right hind-wing seems to be folded back on itself, and the radius vein is the first distinguishable. It is more branched than its fellow of the fore-wing, giving

off at least five branches, the fourth being forked. These branches reach a portion of the outer side, and apex of the wing, and the whole of the inner side of the apical margin. More inward is seen the distal half of another vein which may be the median. It separates into two branches which reach the distal part of the inner margin. The anal area is hidden by being folded in against the body.

The wings appear too small and of too rigid a type to have been serviceable for flight, and the elongated abdomen could not have been supported by such rudimentary wings. The size and condition of the hind-wings shows that the great increase in width over that of the tegmina in the adult form is a comparatively late development, and probably synchronised with the shortening up of the abdomen.

The proximal segments of the abdomen are obscure, but beyond the dislocation can be seen four well-rounded segments, followed by the crushed terminal segment and indications of one of the cerci.

Affinities.—The generic name attached to these specimens by Dr. Woodward is of doubtful value, since in the present state of our knowledge it is impossible to assign larvæ to the adult forms of which they are the immature representatives. The only adult forms known from the same beds are *Archimylacris johnsoni*, *A. eggintoni* and *A. incisa*.

Order PROTODONATA (Brongniart), Handlirsch.

1906. Handlirsch, Die Fossilen Insekten, p. 304.

Large insects with slender bodies similar to those of the Odonata. Wings large, outspread in the condition of rest, and only capable of an up and down movement in one place. Wing-neuration specialised by the union of several longitudinal veins into accessory or interpolated sectors. Cross-nervures well developed in a regular order. Head large, with large eyes and powerful jaws; thorax much as in the Odonata. Legs strong and similar. Antennæ short. Abdomen long.

Family MEGANEURIDÆ, Handlirsch.

1906. Handlirsch, Die Fossilen Insekten, p. 306.

Wings Protodonate in character, with a pre-costal marginal area destitute of veins. Costa almost straight; subcosta simple, and uniting with the costa far out. Radius simple, and followed by a series of accessory veins which represent the radial sector, these all curving towards the distal inner margin. Median

apparently united to the radius at the base, and dividing about the middle of the wing into two widely divergent branches, between which are developed a numerous series of accessory veins. Cubitus (in the type species) consisting of a single undivided vein on the outer side, and of an inner branch which is much subdivided. Anal vein reaching middle of inner margin, and giving off many strongly recurved branches. Inner margin broadly convex. Interstitial neuration consisting of numerous series of straight cross-nervures. Wings membranous.

This family was formed for a small group of insects of enormous size, discovered at Commentry and described by Brongniart.

Genus **MEGANEURA**, Brongniart.

1885. *Meganeura*, Brongniart, Bull. Soc. Amis Sci. Nat. Rouen [3], ann. xxi, p. 60.

Generic Characters.—Gigantic insects with long narrow fore-wings and broader hind-wings. Precostal area extending to the middle of the outer margin. Costa almost straight, powerful, and joined far out by the subcosta. Radius a single strong vein, followed by a radial sector arising from the radius in the fore-wing, and in the hind-wing from the outer branch of the median. Median united with the radius at the base, having a simple outer branch and a much divided inner branch. Many of the branches of the latter accessory. Cubitus with outer and inner branches dividing at the base of the wing, and curved in an S-shape. The inner branch well divided, the outer feebly so. Anal veins numerous, strongly curved to the inner margin.

Genus **BOLTONITES**, Handlirsch.

1919. *Boltonites*, Handlirsch, Revision der Paläozoischen Insekten, p. 61.

Generic Characters.—Pre-costal field very small; cubitus and anal veins much as in *Gilsonia titana*, Meunier. "The bridge clearly preserved." By this I understand that Handlirsch alludes to the transverse vein which I described as an "oblique inward branch of the cubitus joining on to the anal." Cubitus and anal with few branches.

Boltonites radstockensis (Bolton). Plate X, fig. 1; Text-figure 44.

1914. *Meganeura radstockensis*, Bolton, Quart. Journ. Geol. Soc., vol. lxx, p. 119, pls. xviii, xix.
1919. *Boltonites radstockensis*, Handlirsch, Revision der Paläozoischen Insekten, p. 61.

Specific Characters.—Outer wing-margin thickened, coriaceous and tuberculate. Outer and inner wing-margins spinulose. Cubital-anal vein present. Areolæ

(? aborted spiracles) in anal area. Length of wing when complete about 190 mm. or seven and a half inches.

Type.—Proximal third of wing, in dark shale with plant-remains; Sedgwick Museum, Cambridge.

Horizon and Locality.—Upper Coal Measures; Tyning Colliery, Radstock, Somersetshire. Precise horizon uncertain.

Description.—The fragment consists of the proximal portion only of a wing, 64 mm. long and 40 mm. in greatest width, and appears to have formed about one-third of the whole. The wing has also been broken along the middle, and a portion lost, due apparently to the shale breaking irregularly, and leaving an uneven surface. The outer and inner parts of the wing-fragment still retain their normal position relatively to each other, but a portion of the inner part of the base is missing.

The outer part of the specimen consists of two veins, the costa and sub-costa. The inner portion shows the cubital and anal veins. The veins missing are therefore the radius and median.

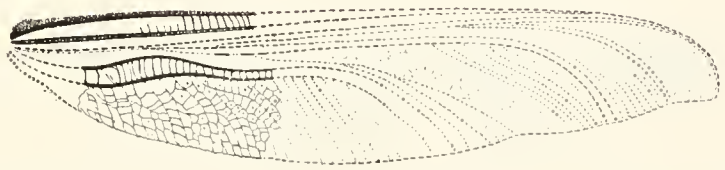


Fig. 44.—*Boltonites radstockensis* (Bolton); restoration of right wing, based on that of *Meganeura monyi*, Brongt., one-half natural size. Upper Coal Measures (precise horizon uncertain); Tyning Colliery, Radstock, Somerset. Sedgwick Museum, Cambridge.

The outer wing-margin consists, not of a free alar expansion, as is usual in the Protodonata, but of a coriaceous and tuberculated mass, which is well marked off from the costa along its whole length. This thickened mass apparently represents the free alar development seen in other members of the group.

That other veins existed in the middle area of the wing is proved by the remains of three short portions of a vein, lying in the middle of the interspace. Not until these fragmentary vein-structures had been perceived, and the type of *Meganeura monyi* studied in the Museum at the Jardin des Plantes, Paris, could its relationship with the Protodonata be confirmed. The direct comparison of the two wings also showed that the Radstock specimen had the same parallelism of the principal veins, the co-existence of similar cross-veins, and the same distinctive character of the anal area as *M. monyi*.

The basal portion of the outer margin of the Radstock wing is swollen into an elongated mass, which thins out distally, and probably did not extend beyond the proximal third of the wing. It can be traced for a length of 20 mm., and near the articulation is covered with numerous low, smooth-topped tubercles, arranged

irregularly. The more median part of the costal margin appears as a flat, straight, knife-like edge, crossed by a series of fine striations.

The thickened pre-costal portion of the outer margin forms a rigid bar, enormously strengthening the wing for flight. The costa is distinct, and passes directly to the wing-apex, as a broad, strap-shaped vein, broadest at its point of origin, and slowly diminishing in width to the tip of the wing.

The subcosta has an apparent union at its base with the costa, but this is due to a slight backward displacement of the latter. Some distance beyond the thickened margin, the costa bears, at regular intervals, a series of low spines, projecting freely forwards, and gradually inclining towards the wing-apex. A few scattered tubercles, and a faint ridge, are seen along the middle of the vein, and eventually die out. The distal part of the costa is straight, and is joined to the subcosta by a series of transverse branches which are well marked. Of these branches, eleven are still whole, and portions of nine others can be made out. It would therefore seem that the whole of the costal area was covered by a parallel system of straight cross-branches with no intervening network.

The subcosta arises in close contact with the costa, diverging rapidly until the two are about 5—6 mm. apart. Once this distance has been attained, they remain nearly parallel for some distance. There are indications that the two come together some distance beyond the broken edge of the wing-fragment.

The costa and subcosta are nowhere more than 5—6 mm. apart, in the main but 4 mm., the interval narrowing to the broken edge of the wing. While the subcosta has the same flat, strap-shaped character as the costa, it is more delicate, and a narrower vein. A few tubercles are disposed along the median line of its length.

The radius and median veins being lost, except for the trivial pieces already noted, they cannot be compared with those of *Meganeura*. In the French species of this genus a complex of parallel veins arises from one or two roots between the subcosta and the cubitus. In the case of *M. monyi*, this complex arises from a strong radius and a weak median. In *M. selysii* it would appear that the radius and median are united at their base. In the restoration of the Radstock wing it will be seen that the vein-fragments appear as parts of the median vein, the radius being wholly lost.

The cubitus is separated from the outer part of the wing by the interval formerly occupied by the radius and median. This interval is variable in width, owing to the strong curvature of the cubitus. This is a large flattened vein, strongly flexuous, and finally curving inwards to reach the middle of the inner margin. The base of the vein has been broken away and lost, but its course may be indicated by a faint groove which curves forward towards the base of the subcosta. The outer inward curve of the cubitus is the greater, so that the interval between the radius and the subcosta becomes increasingly wide, thus

agreeing exactly with what obtains in the same part of the wing in *Meganeura monyi*. It is an indication of the rapid inward curvature which takes place a little further out, and of the presence in the complete wing of the wide distal area occupied by the many branches of the radius and the median.

Close to the basal broken end of the cubitus a strong oblique inward vein is given off, which reaches the anal vein, and fuses with it. At the time when I first described this wing I wrote as follows: "It has the appearance of an important commissure between the cubitus and the anal, or of a posterior branch of the former which has fused with the latter." Since then, Dr. R. J. Tillyard has published the results of his studies on recent dragon-flies ('The Biology of Dragon-flies,' Cambridge University Press, 1917), in which he notes our discovery of this oblique vein. He recognises it as an anal-cubital vein which he had previously ('Proc. Linn. Soc., N.S.W.,' vol. xxxix, pp. 163—216, 1914) described as indicating the point where the true anal vein diverges from the cubitus. He concludes (*op. cit.*, p. 305): "Hence it would appear that *Cu* (cubitus) and *A* (anal) were fused basally as in all recent forms. Thus the gap between Protodonata and Odonata is being gradually lessened until to-day we may almost certainly see in the Meganeuridæ the giant relatives of the direct ancestors of some at least of our recent families."

Beyond this anal-cubitus vein the cubitus is joined to the anal by a system of parallel slightly curved branches, similar in character to those which unite the sub-costa and the costa. No fewer than twenty-five of these branches can be distinguished. Basally to the anal-cubital vein are two transverse branches, a little more curved than the rest. As in the costa and sub-costa, a median line of tubercular ornament is present.

The anal vein is strongly marked, and its course is much similar to that of the cubitus, but the second inward flexure is less marked, so that the two veins are closer together in the middle of their length, and more widely separated basally. The anal gives origin, along the whole length of its hinder margin, to a series of branches, which arise at slightly increasing intervals, being closest basally, and most widely separated between the twelfth and thirteenth branches, beyond which the interspaces narrow again to the fifteenth branch. The basal branches pass in straight or slightly oblique lines inwards to the wing-margin. Further out they become curved, with the convexity outwards. The twelfth branch is a strong and important vein, sweeping in a powerful double curve distally, and inwardly to the wing-margin. It corresponds in position to Brongniart's "vein X." Beyond it are the remains of three feebler branches, which bend in simple curves to the margin.

The spaces between the anal branches are divided up into a series of quadrangular areas or cellules, by a great series of secondary branches, arising at right-angles. The twelfth dorsal branch stands out from the rest by reason of its

robust character and sweeping curve, and gives off, on its inner side, a series of twigs, which divide and separate so widely that first a double and then a treble series of cellules are enclosed between them. On its distal side it intercepts five branches arising from the inner border of the main stem of the anal, the enclosed quadrangular areas being increasingly elongated antero-posteriorly up to the eighteenth branch, the course of that branch to the margin being uninterrupted. The integument in many of the quadrangular areas or cellules is marked by a slight central elevation, which, under high magnification, presents the appearance of a circular thickened lip, with a central depression or perforation. These structures have no regularity of arrangement, but are most numerous on each side of the twelfth branch of the anal. The integument within the cellules is, in some instances, obliquely wrinkled. These structures appear to resemble aborted spiracles.

The inner margin of the wing is sharply sloped forwards from the broken edge onwards to the point of attachment, and is well-defined and spinous along the whole or the greater part of its length. The spines are low, directed distally, and in character somewhat like those on the outer margin of the wing. They are not so clearly shown, however, and they may not be truly marginal, as it is a matter of doubt whether the integument stretches a little outside them. I incline to the latter view. The ventral surface of the wing seems to be uppermost, in which case the wing-fragment is the proximal portion of a right wing.

Affinities.—The general characters of the wing-fragment are those typical of the genus *Meganeura*, and it cannot be confused with the genus *Paralogus*. It is, however, unlike *M. monyi*, in which the development of marginal spines has not been recorded, and the tuberculation so characteristic of the Radstock wing is not shown in that species. *M. monyi* is a wider and longer wing, and does not possess the areolæ seen in the quadrangular cellules of this species.

Considered as a Meganeurid wing, the Radstock specimen is no primitive structure, but highly specialised, an anal cubitus connection is present, the costal border has become thickened and tuberculated, and a secondary development of spinules and tuberculations has arisen.

INCERTÆ SEDIS.

Genus **TILLYARDIA**, novum.

Generic Characters.—Wings elongated, five times as long as wide. Subcosta short; radius simple, radial sector forming an accessory vein with several divisions. Median vein with few branches. Cubitus with two main branches, the inner much

divided. Accessory sectors present. Interstitial neuration forming a regular series of straight cross-nervures.

I refer to this genus a highly specialised wing from the Scottish Coal Measures, which is unlike any other Carboniferous wing that I know. It is at once suggestive of the Palæodictyoptera and of the Protodonata, but belongs, I believe, to the latter Order. Where shown, the neuration of the wing is clear, and the absence of the outer part of the base, and the central portion of the wing, renders it difficult to determine the actual course of certain veins and their true nature.

I have much pleasure in naming this genus after Dr. R. J. Tillyard, whose researches on the venation of the wings of nymphs of recent insects have helped to interpret the older fossil forms.

Tillyardia multiplicata, sp. nov. Plate X, fig. 2; Text-figure 45.

Type.—Greater part of the impression of the under surface of a right wing; Museum of Geological Survey of Scotland, Edinburgh (no. T. 4098*b*).

Fig. 45.—*Tillyardia multiplicata*, sp. nov.; diagram of venation of right wing, enlarged one-and-a-half times. Upper Coal Measures; Barony Pit, Auchinleck, Ayrshire. Museum of Geological Survey of Scotland, Edinburgh (no. T. 1098 *b*).

Horizon and Locality.—Upper Coal Measures; Barony Pit, Auchinleck, Ayrshire.

Specific Characters.—As above.

Description.—The wing lies on the irregular surface of a soft purple sandstone, is imperfect, and has been badly rubbed, so that the junctions of some of the veins have been obscured. The whole of the base of the wing is missing, and the middle portion of the impression of the wing has also been destroyed. It is 67 mm. long and 13 mm. wide.

The outer margin appears to have been almost straight over the greater part of its length, inclining gently into the wing-apex, the latter joining the inner margin in a blunt right-angle. By analogy with the Protodonata, the outer margin was extended outwardly in its basal half, and the subcostal area was widened out. This feature is seen in *Paralogus æschnoides*, Scd., with which the wing has much in common. No trace of an undoubted subcostal vein is distinguishable. It must therefore have been short, and joined to the outer margin in the basal half. The radius is a long vein, parallel with the outer margin, and

reaching the wing-apex, curving inwards as it does so. The junctions of the branches of the radial sector are destroyed. It would seem to have begun between the radius and the median as an accessory vein, rather than as an offshoot of the radius. Its branches occupy the outer half of the wing-apex. The median is a large and important vein, dividing near the base into two branches. The outer branch is undivided until close to the distal end of the outer margin, where it gives off an outer and two inner twigs. The inner branch of the median gives off five simple inner twigs, and an outer one which forks close to the margin. The cubitus is represented by two veins, an outer vein which remains undivided and an inner which gives off at least five twigs. It is possible that the vein which I thus describe as the cubitus is really part of a cubito-anal, but as the basal part is missing the exact conditions cannot be determined. The inner margin of the wing is nearly straight.

Affinities.—The wing-structure, so far as it can be made out, is much like that of *Paralogus æschnoides*, Scd., and *Protagrion audouini*, Brong., and of these it more nearly accords with the latter in its great length as contrasted with the breadth. The plication of the wing is unusually well developed, and is a feature best seen in *P. æschnoides*. The presence of accessory sectors is again a feature seen in *Protagrion*. The general wing-structure, therefore, has certain characters of both genera, and where it departs from the one it approaches the other.

ADDENDUM.

Archimylacris pringlei, Bolton. Plate X, fig. 3.

1921. *Archimylacris pringlei*, Bolton, Quart. Journ. Geol. Soc., vol. lxxvii, pp. 23—29, pl. i, figs. 1–2, text-fig. 1.

Type.—The basal two-thirds of a fore-wing, and counterpart impression, partly obscured by plant remains; Museum of Practical Geology, Jermyn Street (nos. 30725, 30726).

Horizon and Locality.—Keele Group, Upper Division of the Coal Measures; from rocks between the surface level and 97 feet in borehole at Slang Lane, Wellington, Shropshire.

Specific Characters.—Wing twice to two-and-a-half times as long as wide, costal margin flattened; subcostal area strap-shaped and very wide, crossed by numerous parallel branches of the subcosta. Radius dividing beyond middle of wing. Median parallel with radius. Cubitus curving to inner margin, with widely separated inward branches. Anal area long.

Description.—The wing-fragment has a length of 18 mm. The costal margin

is flatly convex over the greater part of its length, and well rounded at the base of the wing. The subcosta is parallel to and widely spaced from the outer margin, to which it sends eight or nine branches, two of which are forked, and one, the most distal, is not fully developed. The radius is not complete, and has but a slight divergence from the subcosta. It gives off the radial sector at a point between the seventh and eighth branches of the subcosta. The radial sector goes out to the wing-apex, sending its branches forward to the outer margin. The median diverges a little more from the radius than the latter from the subcosta. Portions of three inner branches are present. The cubitus is a convex vein passing well out to the distal end of the inner margin of the wing, and giving off a series of widely separated inward branches, of which four are present on the wing-fragment preserved. Owing to the forward displacement of the anal portion of the wing, the first branch of the cubitus passes under the first anal vein. The second shows a simple fork, and the remaining two veins end undivided on the line of fracture. Portions of six anal veins are present, the first obscure and the rest parallel. The interstitial neuration consists of a compact series of close-set transverse nervures, which in the basal areas between the radius, median, and cubitus unite laterally and irregularly until they form a coarse irregular meshwork.

Affinities.—The widely spaced subcosta and the character of the interstitial neuration of the wing show a close relationship to that of two forms of *Archimylacris* (*A. desaillyi* and *A. lerichei*) recorded from the Coal Measures of Liévin, Northern France, but, as the accompanying tabulated comparison will show, the wing is nevertheless specifically distinct from either.

Observations.—The presence of this fossil Blattoid in the Keele Group of the Upper Division of the Coal Measures of Shropshire, and its specific relation to forms known only from the Westphalian Series of Liévin, Northern France, is a matter of considerable interest, especially as Dr. Pruvost, of Lille, had previously drawn attention to the fact that the fauna at the top of the Coal Measures in Great Britain (Keele Group, Newcastle-under-Lyme Group, Etruria Group) does not notably differ from the fauna at the top of the Westphalian in Northern France.

Tabulated Comparison.

A. pringlei, Bolton.	*A. desaillyi*, Leriche.	*A. lerichei*, Pruvost.
Costal Area :		
Strap-shaped, widely spaced from wing-margin.	Strap-shaped, widely spaced from wing-margin.	Outer third oblique to wing-margin.
Subcostal Vein :		
Numerous divisions, mostly forking.	Numerous divisions, mostly forking.	Few divisions, much branched,

A. pringlei, Bolton.	*A. desaillyi*, Leriche.	*A. lerichei*, Pruvost.
Radius Vein:		
Few branches. Radial sector arising opposite outer fourth of subcosta.	Seven branches. Radial sector arising opposite outer third of subcosta.	Twelve branches. Radial sector arising opposite middle of subcosta.
Radial Sector:		
Branching not known.	Eight branches.	Seven to eight branches
Median Vein:		
Branches beyond origin of radial sector.	Branches opposite first fork of radial sector.	Branches much beyond origin of radial sector.
Cubitus Vein:		
First branch simple, second forked.	First branch simple, second and third forked.	First branch dividing into four, second simple, third and fourth branched.
Anal Veins:		
Undivided.	First vein only forked.	First anal forking twice.
Interstitial neuration:		
Transverse nervures, except in the median basal part of the wing, where it is reticulate.	Transverse nervures, except in the median basal part of the wing, where it is reticulate.	Transverse nervures, except in the median basal part of the wing, where it is reticulate.

BIBLIOGRAPHY.

Audouin, V. "Sur une Empreinte d'Aile d'un Insecte névroptère inconnu, trouvé en Angleterre à Coalbrookdale dans le Shropshire, dans un Terrain Houiller," 'Ann. Soc. Entom. France,' vol. ii, 'Bull. Entom.,' pp. 7—8, 1833.

Allen, H. A. "On an Insect from the Coal Measures of South Wales," 'Geol. Mag.' [4], vol. viii, pp. 65—68, 1901.

Baldwin, W. "Fossil Myriapoda from the Middle Coal Measures of Sparth Bottoms, Rochdale, Lancashire," *ibid.* [5], vol. viii, pp. 74—80, 1911.

Binney, E. W. "On two Remarkable Fossil Insects from the Lower Coal Measures, near Huddersfield," 'Proc. Lit. and Phil. Soc. Manchester,' vol. vi, p. 59, 1867.

Bolton, H. "Notes on the Geological Horizon and Palæontology of the 'Soapstone Bed' in the Lower Coal Measures near Colne, Lancashire," 'Geol. Mag.' [5], vol. ii, pp. 433—437, 1905.

——— "On a New Species of Fossil Cockroach from the South Wales Coalfield," *ibid.* [5], vol. vii, pp. 147—151, 1910.

——— "Insect Remains from the South Wales Coalfield," 'Quart. Journ. Geol. Soc.,' vol. lxvii, pp. 149—174, pls. vii—x, 1911.

——— "Faunal Horizons in the Bristol Coalfield," *ibid.*, vol. lxvii, pp. 316—341, pl. xxvi, 1911.

——— "Insect Remains from the Midland and South-Eastern Coal Measures," *ibid.*, vol. lxviii, pp. 310—323, pls. xxxi—xxxiii, 1912.

Bolton, H. "On the Occurrence of a Giant Dragonfly in the Radstock Coal Measures," *ibid.*, vol. lxx, pp. 119—127, pls. xviii, xix, 1914.

—— "Fauna and Stratigraphy of the Kent Coalfield," 'Trans. Inst. Min. Engin.,' vol. xlix, pp. 643—702, 1915.

—— "On some Insects from the British Coal Measures," 'Quart. Journ. Geol Soc.,' vol. lxxii, pp. 43—62, pls. iii, iv, 1916.

—— "The Mark Stirrup Collection of Fossil Insects from the Coal Measures of Commentry (Allier), Central France," 'Mem. and Proc. Manchester Lit. and Phil. Soc.,' vol. xli, pp. 153—175, pls. i—iv, 1917.

—— "On Blattoid and other Insect-Remains from the South Staffordshire Coalfield," 'Mem. and Proc. Birmingham Nat. Hist. and Phil. Soc.,' vol. xiv, pp. 100—106, pl. vii, 1917.

—— "A New Species of Blattoid (*Archimylacris*) from the Keele Group (Radstockian) of Shropshire," 'Quart. Journ. Geol. Soc.,' vol. lxxvii, pp. 23—29, pl. i, 1921.

Borre, A. Preudhomme de. "Note sur des Empreintes d'Insectes fossiles découvertes dans les schistes houillers des environs de Mons," 'Comptes-rendus Soc. Entom. Belg.' [2], vol. xii, pp. 4—8, 1875.

—— "Complément de la note sur des Empreintes d'Insectes fossiles," *ibid.* [2], vol. xiii, pp. 7—11, 1875. (In this complementary note, de Borre replaces the generic name *Pachytylopsis* by *Breyeria*.)

Brauer, F. "Ansichten über die palaeozoïschen Insekten und deren Deutung," 'Ann. k. k. Naturh. Hofmus. Wien,' vol. i, pp. 87—125, pls. vii—viii, 1886.

Brodie, P. B. "Fossil Insects in the Carboniferous Rocks," 'Geol. Mag.,' vol. iv, pp. 285, 286, 1867.

—— "The Distribution and Correlation of Fossil Insects, and the Supposed Occurrence of Lepidoptera and Arachnidæ in British and Foreign Strata, chiefly in the Secondary Rocks," 'Ann. Rep. Warwick. Nat. and Archæol. Field Club,' pp. 12—28, 1873; also pp. 16—38, 1874.

—— "On the Character, Variety and Distribution of the Fossil Insects in the Palæozoic (Primary), Mesozoic (Secondary), and Cainozoic (Tertiary) Periods, with an account of the more Recent Discoveries in this Branch of Palæontology up to the Present Day," *ibid.*, pp. 1—22 (1889), 1890.

Brongniart, C. J. E. 'Récherches pour servir à l'histoire des Insectes Fossiles. Les Hymenoptères fossiles,' fasc. 1, p. 22, Paris, 1881.

—— "La Présence d'articulés dans les terrains siluriens," 'Bull. Soc. Entom. France,' pp. 236—237, 1884.

—— "Sur la Découverte d'une Empreinte d'Insecte dans les grès siluriens de Jurques (Calvados)," 'Comptes rendus Acad. Sci.,' vol. xcix, pp. 1164—1165, 1885.

—— "Les Insectes Fossiles des Terrains Primaires. Coup d'œil rapide sur la faune entomologique des terrains paléozoiques," 'Bull. Soc. Amis Sci. Nat. Rouen,' ser. 3, ann. xxi, pp. 50—68, pls. i—iii, 1885.

—— 'Récherches pour servir à l'histoire des Insectes Fossiles des Temps Primaires; precedées d'une Étude sur la nervation des Ailes des Insectes,' St. Etienne, 1893.

Buckland, W. "Geology and Mineralogy considered with Reference to Natural Theology" (Bridgwater Treatise VI), ed. 2, vol. i, pp. 16, 619; vol. ii, pp. 7, 111, pls. i—lxix, 1837.

—— "Anniversary Address to the Geological Society," 1841, 'Proc. Geol. Soc. London,' vol. iii, pp. 469—510, 1842.

Cockerell, T. D. A. "British Fossil Insects," 'Proc. U.S. Nat. Mus.,' vol. xlix, pp. 469—499, pls. lx—lxv, 1915.

Comstock, J. H. 'The Wings of Insects,' Comstock Publishing Company, Ithaca, N.Y., 1918.

—— and Needham, J. G. "The Wings of Insects." 'American Naturalist,' vols. xxxii and xxxiii, 1898—99.

Dawson, J. W. "On some Remains of Palæozoic Insects recently discovered in Nova Scotia and New Brunswick," 'Canadian Naturalist,' n.s., vol. iii, pp. 202—206, fig. 5, 1867; also 'Geol. Mag.,' vol. iv, pp. 385—388, pl. xvii, figs. 1—5, 1867.

—— "Acadian Geology," pp. 27, 694,; pl. (9), map, figs. 231 (1), 1868.

—— "Note on Some New Animal Remains from the Carboniferous and Devonian of Canada," 'Quart. Journ. Geol. Soc.,' vol. xxvi, p. 166, 1870.

Goldenberg, F. "Die Fossilen Insecten der Kohlenformation von Saarbrücken," 'Palaeontographica,' vol. iv, pp. 17—38, pls. iii—vi, 1854.

—— 'Fauna Saraepontana Fossilis. Die Fossilen Thiere aus der Steinkohlenformation von Saarbrücken,' Saarbrücken, 1873—77.

Goss, H. "Palæozoic Time. On the Insects of the Devonian Period, and the Animals and Plants with which they were correlated," 'Entom. Monthl. Mag.,' vol. xv, pp. 124—127, 1878.

—— "Palæozoic Time. On the Insects of the Carboniferous Period, and the Animals and Plants with which they were correlated," *ibid.*, vol. xv, pp. 169—173, 1879.

—— "Palæozoic Time. On the Insects of the Permian Period, and the Animals and Plants with which they were correlated," *ibid.*, vol. xv, pp. 226—228, 1879.

—— "The Insect Fauna of the Primary or Palæozoic Period," 'Proc. Geol. Assoc.,' vol. vi, pp. 271—300, 1879—80.

—— "The Geological Antiquity of Insects." Twelve Papers on Fossil Entomology reprinted, with some alterations and additions, from vols. xv and xvi of the 'Entom. Monthl. Mag.,' pp. (2) 50. London, 1880.

—— "On some Recently Discovered Insects from Carboniferous and Silurian Rocks," 'Proc. Geol. Assoc.,' vol. ix, pp. 131—151, 1885.

Handlirsch, A. "Les Insectes Houillers de la Belgique," 'Mém. Mus. Roy. Hist. Nat. Belg.,' vol. iii, no. 1, pp. 1—20, pls. i—vii, 1904.

—— "Revision of American Palæozoic Insects," 'Proc. U.S. Nat. Mus.,' vol. xxix, pp. 661—820, 1906.

—— 'Die Fossilen Insekten,' Leipzig, 1906—8.

—— "Die Bedeutung der Fossilen Insekten für die Geologie," 'Mitth. Geol. Gesell. Wien,' vol. iii, pp. 503—522, 1910.

—— "New Palæozoic Insects from the Vicinity of Mazon Creek, Illinois," 'Amer. Journ. Sci.' [4], vol. xxxi, pp. 297—377, 1911.

Handlirsch, A. Article on "Sub-phylum Insects" in 'Zittel's Text-book of Palæontology,' adapted from the German by C. R. Eastman, ed. 2, vol. i, pp. 794—821, London, 1913.

—— "Revision der Palaeozoïschen Insekten," 'Denkschr. Akad. Wiss. Wien, math.-naturw. Cl.,' vol. xlvi, pp. 511—592, 1919.

Heilprin, A. 'The Geographical and Geological Distribution of Animals,' pp. 51, 146, 279. Inter. Sci. Series, London, 1887.

Higgins, H. H. "Presidential Address," 'Proc. Liverpool Nat. Field Club,' vol. ii, pp. 9—19, 1871.

Kirkby, J. W. "On the Remains of Insects from the Coal Measures of Durham," 'Geol. Mag.,' vol. iv, pp. 388—390, pl. xvii, figs. 6—8, 1867.

Lameere, A. "Note sur les Insectes Houillers de Commentry," 'Bull. Soc. Zool. France,' vol. xlii, pp. 27—37, 1917.

—— "Révision Sommaire des Insectes Fossiles du Stephanien de Commentry," 'Bull. Mus. Hist. Nat. Paris,' pp. 141—200, 1917.

Lubbock, J. 'On the Origin and Metamorphoses of Insects.' Nature Series, London, 1874.

—— "Address to Entomological Society of London at the Anniversary Meeting, January 19th, 1881," 'Proc. Entom. Soc. London,' for 1880, pp. xli—lv, 1881.

Mantell, G. A. 'The Wonders of Geology,' 1st American from 3rd London edition, vol. i, pp. 16, 1—428, front., pl. iv; vol. ii, pp. 7, 429—804 (24), pls. vi—x, New Haven, 1839. Also 7th London edition, 1857.

—— 'Medals of Creation,' 2nd edition, vol. i, pp. 32, 1—446; vol. ii, pp. 11, 447—930, London, 1854.

Matthew, G. F. "On some Remarkable Organisms of the Silurian and Devonian Rocks in Southern New Brunswick," 'Trans. Roy. Soc. Canada,' vol. iv, sect. iv, pp. 49—62, pl. iv, 1889.

Moysey, L. "On some Arthropod Remains from the Nottingham and Derbyshire Coalfield," 'Geol. Mag.' [5], vol. v, pp. 497—507, 1911.

Miall, L. C. "Coal Measure Insects" in 'Coal, its History and Uses,' by Profs. Green, Miall, Thorpe, Rücker and Marshall, pp. 154—157, London, 1878.

Murchison, R. I. 'Siluria.' Notices Insects of the Coal, p. 284. London, 1854; also ed. 3, pp. 20, 592, pl. ii. London, 1859; ed. 4, p. 300. London, 1867. (Brief reference to figure of an insect "allied to *Corydalis*" from Coalbrookdale on pp. 320, 321).

Novak, O. "Fauna der cyprisschiefer des egerer Tertiärbeckens," 'Sitzungsb. k. Akad. Wiss. Wien, math.-nat. Cl.,' vol. lxxvi, Abth. 1, pp. 71—96, pls. i—iii, 1878.

—— "Ueber *Gryllacris bohemica*, einen neuen Locustidenrest aus der Steinkohlenformation von Stradonitz in Böhmen," 'Jahrb. k. k. geol. Reichsanst. Wien,' vol. xxx, pp. 69—74, pl. ii, 1880.

Parkinson, J. 'Organic Remains,' vol. iii, p. 258. London, 1804—1811.

Pictet, F. J. "Sialidæ," in 'Traité de Paléontologie,' ed. 2, 1854.

Pocock, R. I. "Monograph of the Terrestrial Carboniferous Arachnida of Great Britain," 'Pal. Soc.,' 1911.

Prestwich, J. "On the Geology of Coalbrookdale," 'Trans. Geol. Soc. London' [2], vol v, pp. 413—495, pls. xxxv—xli, 1840.

Pruvost, P. "Les Insectes Houillers du Nord de la France," 'Ann. Soc. Géol. Nord,' vol. xli, pp. 323—380, pls. ix—xii, 1912.

—— "La Faune Continentale du Terrain Houiller du Nord de la France. Introduction à l'étude du Terrain Houiller du Nord et du Pas-de-Calais," 'Mém. l'Explic. Carte dét. France.' Ministère des Travaux Publics, Paris, 1919 (? 1920).

Scudder, S. H. "On an English Fossil Insect described as Lepidopterous," 'Proc. Boston Soc. Nat. Hist.,' vol. xvi, pp. 16, 112, 1874.

—— Palæozoic Cockroaches," 'Mem. Boston Soc. Nat. Hist.,' vol. iii, pp. 23—134, pls. ii—vi, 1879.

—— "Two New British Carboniferous Insects, with Remarks on those already known," 'Geol. Mag.' [2], vol. viii, pp. 293—300, 1881.

—— Abstract: "Upon the Carboniferous Insects of Great Britain," 'Harvard Univ. Bull.,' no. ii, p. 175, 1881.

—— "A Bibliography of Fossil Insects," 'Bibliographical Contributions, Library of Harvard University,' pp. 1—47, 1882.

—— "Archipolypoda, a Sub-ordinal Type of Spined Myriapods from the Carboniferous Formation," 'Mem. Boston Soc. Nat. Hist.,' vol. iii, pp. 143—152, 1883.

—— "Two More English Carboniferous Insects," 'Geol. Mag.' [3], vol. ii, pp. 265, 266, 1885.

—— "Handbuch der Palaeontologie. Classe Insekten," by S. H. Scudder, pp. 747—831, München und Leipzig, 1881—1885.

—— Article "Insecta" in 'Zittel's Traité de Paléontologie,' trans. by C. Barrois, vol. ii, pp. 748—833, Paris, 1887.

—— "Insect Fauna of the Rhode Island Coalfield," 'Bull. U.S. Geol. Surv.' no. 101, 1893.

—— "Revision of the American Fossil Cockroaches, Description of New Forms," *ibid.*, no. 124, 1895.

Sellards, E. H. "A Study of the Structure of Palæozoic Cockroaches, with Descriptions of New Forms from the Coal Measures," 'Amer. Journ. Sci.' [4], vol. xviii, pp. 113—134, pl. i, 1904.

—— "A Study of the Structure of Palæozoic Cockroaches, with Descriptions of New Forms from the Coal Measures," *loc. cit.*, pp. 213—227, 1904.

Stobbs, J. T. "Fossil Insect from the Coal Measures of North Staffordshire," 'Geol. Mag.' [4], vol. x, p. 524, 1903.

Swinton, A. H. "Notes on Certain Fossil Orthoptera claiming Affinity with the Genus *Gryllacris*," 'Geol. Mag.' [2], vol. i, pp. 337—341, 1874.

Tillyard, R. J. "On Some Problems concerning the Development of the Wing-Venation of Odonata," 'Proc. Linn. Soc. N. S. Wales,' vol. xxxix, pp. 163—216, 1914.

—— 'The Biology of Dragonflies.' Cambridge University Press, 1917.

TILLYARD, R. J. "The Panorpoid Complex, A Study of the Phylogeny of the Holometabolous Insects, with Special Reference to the Subclasses Panorpoidea and Neuropteroidea (Introduction)," 'Proc. Linn. Soc. N. S. Wales,' vol. xliii, pp. 265—284, 1918.

—— "The Panorpoid Complex, Part 1. The Wing-coupling Apparatus, with Special Reference to the Lepidoptera," *ibid.*, vol. xliii, pp. 286—319, pls. xxix, xxx, 1918.

—— "The Panorpoid Complex, Part 2. The Wing-tracheation and its Relationship to the General Scheme of Venation," *ibid.*, vol. xliii, pp. 626—657, pls. lxvii—lxix, 1918.

—— "The Panorpoid Complex, Part 3. The Wing Venation," *ibid.*, vol. xliv, pp. 533—718, pls. xxxi—xxxv, 1919.

—— "The Panorpoid Complex, Additions and Corrections to Part 3," *ibid.*, vol. xlv, pp. 214—217, 1920.

WALLACE, A. R. "The Geographical Distribution of Animals," vol. i, pp. 24, 503, pl. xiii; vol. ii, pp. 10, 607, pl. vii, London, 1876.

WOODWARD, H. "On the Discovery of a New and very perfect Arachnid from the Ironstone of the Dudley Coalfield," 'Geol. Mag.,' vol. viii, pp. 385—388, pl. xi, 1871.

—— "On a Remarkable Fossil Orthopterous Insect from the Coal Measures of Britain," *ibid.* [2], vol. ii, pp. 621—622, 1875.

—— "On a Remarkable Fossil Orthopterous Insect from the Coal Measures of Scotland," 'Quart. Journ. Geol. Soc.,' vol. xxxii, pp. 60—64, pl. ix, 1876.

—— "Some New British Carboniferous Cockroaches," 'Geol. Mag.' [3], vol. iv, pp. 49—58, pl. xi, 1887.

—— "On the Discovery of the Larval Stage of a Cockroach, *Etoblattina peachii*, H. Woodward, from the Coal Measures of Kilmaurs, Ayrshire," *loc. cit.*, pp. 433—435, pl. xii, 1887.

—— "Notes on Some Crustaceans and Two Myriapods from the Lower Coal Measures near Colne, Lancashire," *ibid.* [5], vol. ii, p. 437, 1905.

—— "A Fossil Insect from the Coal Measures, Longton, North Staffordshire," *ibid.* [5], vol. iii, pp. 25—29, 1906.

—— "Some Coal Measure Crustaceans with Modern Representatives," *ibid.* [5], vol. v, pp. 385—396, 1908.

WOOLACOTT, D., and TRECHMANN, C. T. "On the Highest Coal Measures of Durham," *ibid.* [6], vol. vi, p. 203, 1919.

ZITTEL, K. A. VON. 'Handbuch der Palaeontologie.—Classe Insekten,' by S. H. Scudder, pp. 747—831, München und Leipzig, 1881—1885.

—— 'Traité de Paléontologie,' translated by Dr. Charles Barrois, vol. ii, Paléozoologie, Article "Insecta," by S. H. Scudder, pp. 746—833, Paris, Munich, and Leipzig, 1887.

—— 'Text-Book of Palæontology,' by K. A. von. Zittel, translated by Dr. C. R. Eastman, Article "Insecta," by S. H. Scudder, 1st ed., vol. i, pp. 682—691, London, 1900.

INDEX.

Note.—The roman and arabic numerals following a semicolon refer to the plates and figures illustrating those species which are recognised and described.

	PAGE
Ædœophasma	78
— anglica	78; V, 2
Ænigmatodes	71
— danielsi	39, 72
— regularis ...	71; IV, 7
Ænigmatodidæ	70
Aphthoroblattina	96
— eggintoni	100; VI, 6
— johnsoni ...	96; VI, 4, 5
— sulcata	113
Apopappus	53
Archæoptilus	74
— ingens	74; IV, 9
— lucasi	76
Archæotiphe mantidioides	125
Archiblattides	91
Archimylacridæ	96
(Archimylacridæ) kirkbyi ...	118; VIII, 3
Archimylacris	103
— acadica	109
— atrebatica	107
— belgica	105
— hastata	103; VII, 1
— incisa	107; VII, 3
— obovata	109; VII, 4
— pringlei	146; X, 3
— spectabilis	105
— venusta	105
— woodwardi	106; VII, 2
spp.	112, 113; VII, 5, 6
Athymodictya	34
— parva	35
Becquerelia	53, 55
— superba	87
Blattidium mantidioides	125
Blattoid wing-fragments	119, 120; VIII, 5, 6
Blattoidea	93
(Blattoidea) exilis	136
— peachi	134; IX, 6
Boltoniella	56
— tenuitegminata	56; III, 4

	PAGE
Boltonites	140
— radstockensis	140; X, 1
Breyeria	50
— borinensis	52
— lachlani	52
— woodwardiana	50
Breyeriidæ	50
Brodia	58
— fasciata	59
— furcata	66; III, 7, 8
— nebulosa	59
— nympha	63
— petiolata	59
— pictipennis	59
— priscotincta ...	59; III, 5, 6; IV, 1–3
— scudderi	59
Brodiidæ	57
Cacurgus spilopterus	83
Classification	11
Colour bands	61
Compsoneura	53
Cordaites	11, 112
Corydalis brongniarti	45, 46
Coselia	81
— palmiformis	81; V, 3
Coseliidæ	81
Cryptovenia	35
— moyseyi	35; II, 1
Cryptoveniidæ	34
Dictyoneura	25
— higginsii	25; I, 1
— libelluloides	27
Dictyoneuridæ	24
Ephemeroptera	53
Epitethe	53
Etoblattina deanensis	128, 130
— hastata	103
— johnsoni	96
— mantidioides	125

PAGE

Etoblattina peachii 134
— woodwardi 106
Eubleptus 92

Faunal Association 18
Food of Coal Measure Insects ... 10
Fouquea 73
cambrensis 72

Genentomum 84
subacutum ... ... 84; V, 4
Gerablattina sulcata 113
Gerarus 87
Geroneura 76
ovata ... ... 77; V, 1
— wilsoni 78
Graphiptilus 53
Gryllacris brongniarti 45, 46

Habits of Fossil Insects 5
Hadroneura 52
Hemeristia occidentalis 78
Heminylacris 121
convexa ... 123; VIII, 8
obtusa . 122; VIII, 7
— ramificata 123
Hermatoblattina kirkbyi 118
Homaloneura 53
Hypermegethes 32
— northumbriæ ... 32; I, 4
— schucherti 33
Hypermegethidæ 31

Introduction 1

Larval Blattoids 134
Larval Insect Life 7
Lameereites 67
— curvipennis 65
Lamproptilia 53, 56
grandeuryi 57
— stirrupi 57
— tenuitegminata 56
Lamproptilidæ 56
Leptoblattina exilis ... ... 136; IX, 7, 8
Lithomantidæ 42
Lithomantis 42
— carbonarius ... ... 43; II, 4

PAGE

Lithomylacris kirkbyi 118
— pittstonianum ... 118
Lithosialis 45
— brongniarti . 46; III, 1

Mecynoptera 36
— splendida 39
tuberculata .. ... 37; II, 2
Mecynopteridæ 36
Meganeura 140
— monyi ... 141
radstockensis 140
— selysii 142
Meganeuridæ 139
Megaptiloides 52
brodiei 52
Megasecopteridæ 53
Metryia analis 48
Mixotermes luganensis 76
Mixotermitoidea 76
Mode of Occurrence 5
Mylacridæ 120

Necymylacris 127
godoni 124
heros 127
lacoana 127
lafittei 124
— villeti 124

Œdischia 84
Œdischiidæ 84
Omalia macroptera 83
Orthocosta 27
— splendens ... . 27; I, 2
Orthocostidæ 27
Orthomylacris 133
— lanceolata .. ... 133; IX, 5

Palæodictyoptera 24
Palæodictyopteron 25
— higginsii 25
Palæomantis 40
— macroptera ... ... 40; II, 3
Palæoptilus 53
Paralogus 144
Parelthoblatta 105
— belgica 105

	PAGE
Phyloblatta	113
— sulcata	113; VIII, 1
— transversalis ...	115; VIII, 2
— spp.	119; VIII, 4
Phylomylacris	124
— mantidioides	125; IX, 1
Plesioidischia	92
— sp.	92; VI, 3
Polycreagra elegans ...	27
Progenentomum carbonis	93
Protephemeridæ	53
Protoblattoidea	90
Protodonata	139
Protogryllacris brongniarti ...	46
Protophasma dumasii	80
Protorthoptera	78
Pruvostia	48
spectabilis	48; III, 2
Pseudofouquea	72
cambrensis	72; IV, 8
Ptenodera	90
dubius ...	91; VI, 2
Pteronepionites	67
— ambigua	68; IV, 5
— johnsoni ..	68; IV, 4
— lepus	69; IV, 6
Pteronidia	30
— plicatula	30; I, 3
Pteronidiidæ	29
Scalæoptera	88
— recta	88; VI, 1
Schizoblatta alutacea ..	111
obovata ..	109
Schuchertiella	87
Sherborniella ...	27
— higginsii	25
Soomylacris	128
burri	131; IX, 4
deanensis	128; IX, 2
lievinensis	133
— stocki	130; IX, 3
Spilaptera	53
libelluloides	55
packardi	55
sutcliffei	54; III, 3
venusta	55
Spilapteridæ	53
Spiloblattina	112
Spiloptylus	53
Spirorbis pusillus	11, 112
Stenodictya lobata	37, 54
Stobbsia	50
woodwardiana ...	50
Tillyardia	144
— multiplicata ...	145; X, 2
Titanodictya	42
— jucunda	42
Xeroptera	85
— obtusata	85; V, 5

ADLARD AND SON AND WEST NEWMAN, LTD., IMPR., LONDON AND DORKING.

PLATE V.

Fig.		Page.
1.	*Geroneura (?) ovata*, sp. nov.; impression of upper surface of apex of left wing. × 1½. Middle Coal Measures (binds between "Brooch" and "Thick" Coals); British Museum (Madeley Coll.), no. I. 2965.	77.
2 *a*.	*Ædæophasma anglica*, Scudder; almost complete left wing. × 1. Middle Coal Measures; Ravenhead Railway Cutting, near St. Helens, Lancashire. Liverpool Museum.	78.
2 *b*.	Ditto; impression of same. × 1.	78.
3 *a*.	*Coselia palmiformis*, gen. et sp. nov.; basal half of left wing. × 1½. Middle Coal Measures (binds between "Brooch" and "Thick" Coals); Coseley, Staffordshire. British Museum (Johnson Coll.), no. I. 15893.	81.
3 *b*.	Ditto; impression of same showing the intercostal area. × 1½.	81.
4 *a*.	*Genentomum (?) subacutum*, Bolton; apical parts of two wings. × 3½. Lower Coal Measures (637 feet below the Bedminster Great Vein); South Liberty Colliery, Bristol, Somerset. Bristol Museum, no. C. 972.	84.
4 *b*.	Ditto; impression of same. × 3½.	84.
5 *a*.	*Xeroptera obtusata*, gen. et sp. nov.; greater part of right fore-wing lacking the outer margin. × 2. Middle Coal Measures (binds between the "Brooch" and "Thick" Coals); Coseley, Staffordshire. British Museum (Johnson Coll.), no I. 1558.	85.
5 *b*.	Ditto; impression of same. × 2.	85.

Bolton. Insects of Coal Measures.

1. GERONEURA? 2. ÆDŒOPHASMA. 3. COSELIA
4. GENENTOMUM. 5. XEROPTERA.

J. W. Tutcher, photo

Vincent Brooks Day & Son Photo-Litho

PLATE VI.

Fig.		Page.
1 *a*.	*Scalæoptera recta*, sp. nov.; basal half of left wing. × 2. Middle Coal Measures (binds between the "Brooch" and "Thick" Coals); Coseley, nr. Dudley, Staffordshire. British Museum, no. I. 13878.	88.
1 *b*.	Ditto; impression of the same wing-fragment. × 2.	88.
2.	*Ptenodera dubius*, sp. nov.; distal half of left wing. × 3. Middle Coal Measures (binds between the "Brooch" and "Thick" Coals); Coseley, nr. Dudley, Staffordshire. British Museum (Johnson Coll.), no. I. 1559.	91.
3 *a*.	*Plesioidischia*, sp.; fragment of right wing. × 1½. Middle Coal Measures (binds between the "Brooch" and "Thick" Coals); Tipton, Staffordshire. Manchester Museum, no. L. 4905.	92.
3 *b*.	Portion of costal border of same wing borne on opposite half of nodule. × 1½.	92.
4.	*Aphthoroblattina johnsoni* (Woodward); type specimen. × 1½. Middle Coal Measures (binds between the "Brooch" and "Thick" Coals); Coseley, Staffordshire. British Museum (Johnson Coll.), no. I. 1067.	96.
5 *a*.	Ditto. × 2. Middle Coal Measures (binds between the "Brooch" and "Thick" Coals); Coseley, Staffordshire. Mr. W. Egginton's Collection, no. 2.	99.
5 *b*.	Ditto; impression. × 2.	99.
6 *a*.	*Aphthoroblattina egginton*i, sp. nov.; pronotum, portions of tegmina, and the distal portion of left hind-wing showing beyond broken edge of tegmen. × 2. Middle Coal Measures (binds between "Brooch" and "Thick" Coals); Coseley, Staffordshire. Mr. W. Egginton's Collection, no. 1.	100.
6 *b*.	Ditto; counterpart. × 2.	100.

Bolton. Insects of Coal Measures. PLATE XI.

1. SCALÆOPTERA. 2. PTENODERA. 3. PLESIOIDISCHIA.

4-6 APHTHOROBLATTINA.

PLATE VII.

Fig.		Page.
1 *a*.	*Archimylacris hastata*, Bolton; greater part of left fore-wing. × $2\frac{3}{4}$. Base of Upper Coal Measures (Gellideg Level of Mynyddislwyn Vein); near Maes-y-cwmmer, Monmouthshire. Mus. Pract. Geol., no. 24501.	103.
1 *b*.	Ditto; counterpart of left wing. × $2\frac{3}{4}$. Mus. Pract. Geol., no. 24502.	103.
2	*Archimylacris woodwardi*, Bolton; left fore-wing. × $3\frac{1}{2}$. Base of Pennant Series (10 feet shale overlying the No. 2 Rhondda seam); Clydach Vale, South Wales. Mr. D. Davies' Coll.	106.
3 *a*.	*Archimylacris incisa*, sp. nov.; impression of the under surface of the pronotum, and of the remnants of the fore-wings. × 3. Middle Coal Measures (binds between the "Brooch" and "Thick" Coals); Coseley, nr. Dudley, Staffordshire. British Museum (Johnson Coll.), no. I. 15900.	107.
3 *b*.	Ditto: counterpart. × 3.	107.
4 *a*.	*Archimylacris obovata*, Bolton; portion of left fore-wing. × 3. Upper Coal Measures (Gwernau Level of the Mynyddislwyn Vein); Maes-y-cwmmer, Monmouthshire. Mus. Pract. Geol., no. 24506.	109.
4 *b*.	Ditto; impression—less incomplete than the broken wing. × 3. Mus. Pract. Geol., no. 24507.	109.
5.	*Archimylacris*, sp. indet.; fragmentary fore-wing, showing the middle third only, the rest being concealed under a leaf of *Cordaites*, the latter bearing pits in which *Spirorbis pusillus* (Martin) had established themselves. Much enlarged. Base of Upper Coal Measures (Gellideg Level of Mynyddislwyn Vein); near Maes-y-cwmmer, Monmouthshire. Mus. Pract. Geol., no. 24503.	112.
6.	*Archimylacris*, sp. indet.; impression of the basal portion of a left fore-wing, and of a broken pronotum. Much enlarged. Base of Upper Coal Measures (Gellideg Level of Mynyddislwyn Vein); near Maes-y-cwmmer, Monmouthshire. Mus. Pract. Geol., no. 24508.	113.

Bolton. Insects of Coal Measures. PLATE VII

1-6. ARCHIMYLACRIS.

J. W. Tutcher, photo

London Stereoscopic Co. imp

PLATE VIII.

Fig. Page.

1 *a*. *Phyloblatta sulcata* (Bolton); greater part of a right fore-wing. × 3. Upper Coal Measures (Gwernau Level of the Mynyddislwyn Vein); near Maes-y-cwmmer, Monmouthshire. Mus. Pract. Geol., no. 24504. 113.

1 *b*. Ditto; counterpart. × 3. 113.

2. *Phyloblatta transversalis*, Bolton; remains of two Blattoids, consisting of the tegmina, pronota, and portions of the hind-wings. Natural size. Coal Measures; Staffordshire. Geological Museum, University, Birmingham. 115.

3. (Archimylacridæ) *kirkbyi* (Woodward); reproduction of Woodward's figure of a single left wing. × 5. Upper Coal Measures (bed no. 33); Meithil, coast of Fifeshire. Present whereabouts of specimen unknown; formerly in the possession of Mr. James Kirkby. 118.

4 *a*. *Phyloblatta* (?) sp.; portion of Blattoid wing. × 4½. Coal Measures (shales at a depth of 1967 feet); Maydensole boring, Kent. Museum of the Kent Coals Concession Co., Dover. 119.

4 *b*. Ditto; impression. × 4½. 119.

5 *a*. *Phyloblatta* (?) sp.; portion of Blattoid wing. × 4½. Coal Measures (at depth of 2180 feet); Barfreston boring, Kent. Museum of the Kent Coal Concessions Co., Dover. 119.

5 *b*. Ditto; outline of wing-fragment. × 4½. 119.

6. Blattoid wing-fragment. × 4. Found in a core from a depth of 2424 feet at the Stonehall boring, Kent. Museum of the Kent Coal Concessions Co., Dover. 120.

7. *Hemimylacris obtusa*, Bolton; right fore-wing. × 2½. Base of Upper Coal Measures (Four-foot Seam of Swansea); Gladys Colliery, one mile E.S.E. of Penller-gaer Church, Glamorganshire. Mus. Pract. Geol., no. 24510. 122.

8. *Hemimylacris concava*, Bolton; basal half of a fore-wing. × 3½. Coal Measures (shales associated with the Graigola Seam, Pennant Series); Clydach Merthyr Colliery, Clydach Valley, Swansea Vale, Glamorganshire. 123.

Bolton. Insects of Coal Measures.

PLATE VIII.

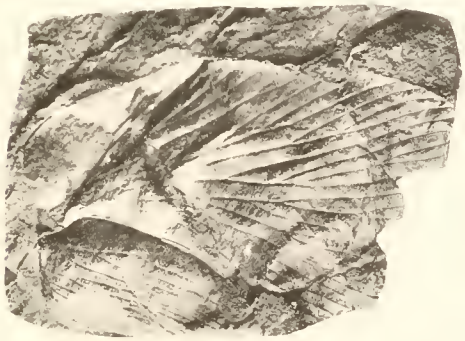
1b. 3/1

2. 1/1

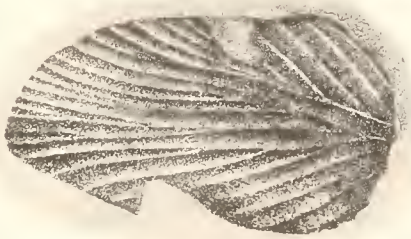
1a. 3/1

4a. 9/2

4b. 9/2



7. 5/2

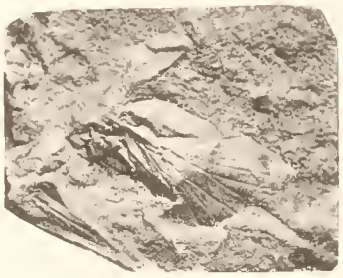


3. 5/1

6. 4/1

5a. 9/2

5b. 9/2



8. 7/2

1. 2. 4. 5. PHYLOBLATTA. 3. ARCHIMYLACRIDAE.

6. BLATTOID WING FRAGMENT. 7. 8. HEMIMYLACRIS.

J. W. Tutcher, photo

London Stereoscopic Co. imp

PLATE IX.

Fig.		Page.
1.	*Phylomylacris mantidioides* (Goldenberg); basal portion of a left fore-wing. × 4½. Upper Coal Measures (zone of *Anthracomya phillipsii*); South Hylton, opposite Claxheugh on the Wear, Durham. Hancock Museum, Newcastle-on-Tyne (Kirkby Coll.).	125.
2.	*Soomylacris deanensis* (Scudder); a right fore-wing, showing the under surface. × 1½. Found by Mr. F. Stock in Coal Measures at Foxe's Bridge, Forest of Dean, Gloucestershire. U.S. National Museum, Washington, D.C. (Lacoe Coll., no. H. 2132 *b*; Nat. Mus., no. 38090).	128.
3.	*Soomylacris stocki*, sp. nov.; fragmentary remains of a fore-wing, partly overlaid by the remains of a second. × 2½. Found by Mr. F. Stock in Coal Measures at Crump Meadow, Forest of Dean, Gloucestershire. U.S. National Museum, Washington, D.C. (Lacoe Coll., no. H. 2132 *c*; Nat. Mus., no. 38090).	130.
4.	*Soomylacris burri*, Bolton; almost complete fore-wing. × 4½. Coal Measures (in dark shale from a depth of 1208 feet); Barfreston Boring, Kent. Museum of the Kent Coal Concessions Co., Dover.	131.
5.	*Orthomylacris lanceolata*, Bolton; left fore-wing, with the base missing. × 2½. Coal measures (shales associated with the Graigola Seam, Pennant Series); Clydach Merthyr Colliery, Clydach Valley, Swansea Vale, Glamorganshire. Mus. Pract. Geol., no. 24511.	133.
6.	(*Blattoidea*) *peachi* (Woodward); complete upper surface of insect, showing the head, pronotum, larval wings, and the segments of the abdomen. × 2½. Coal Measures (grey sandy shale with nodules of impure clay and ironstone, at 91 feet 6 inches below the surface); Greenhill Pit, Kilmarnock. Kilmarnock Museum.	134.
7.	*Leptoblattina exilis*, Woodward; co-type of almost complete insect, seen from the upper surface. × 2. Middle Coal Measures (binds between the "Brooch" and "Thick" Coals); Coseley, Staffordshire. British Museum (Johnson Coll.), no. 1065.	136.
8.	Ditto; a second co-type, with the enlarged epimera well seen on the left side of the abdomen. × 2. British Museum (Johnson Coll.), no. 1066.	136.

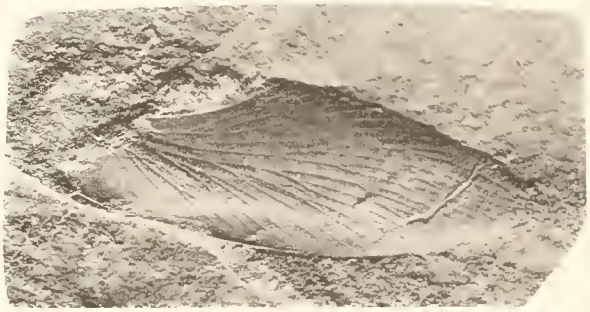
Bolton. Insects of Coal Measures. PLATE IX.

2. 5/2

1. 9/2

4. 9/2

3. 5/2



5. 3/1

6. 5/2

7. 2/1

8. 2/1

1. PHYLOMYLACRIS. 2-4. SOOMYLACRIS. 5. ORTHOMYLACRIS.
6. (BLATTOIDEA.) 7. 8. LEPTOBLATTINA.

J. W. Tutcher, photo London Stereoscopic Co. imp.

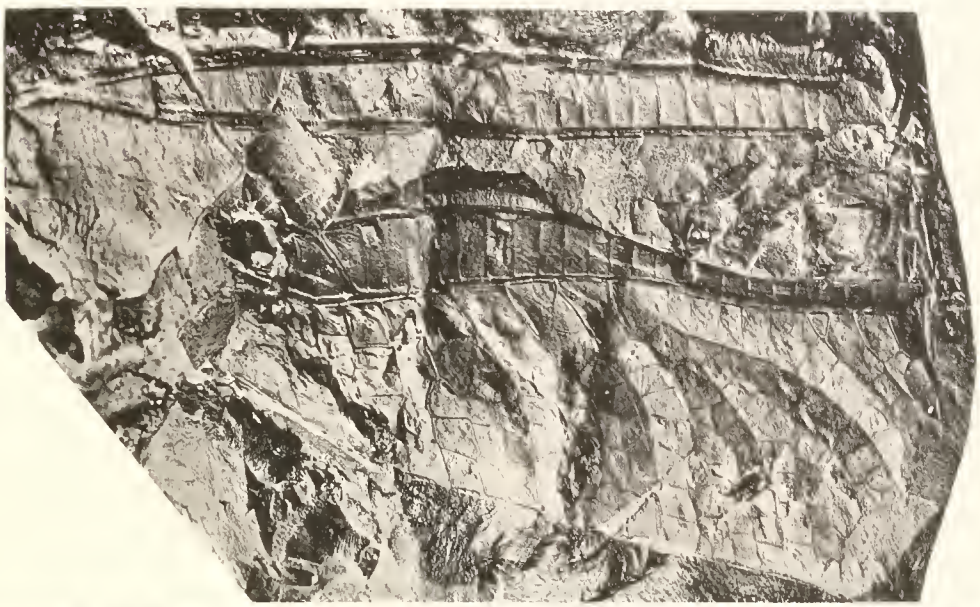
PLATE X.

Fig.		Page.
1*a*.	*Boltonites radstockensis* (Bolton); basal portion of the wing. × 2. Upper Coal Measures; Tyning Colliery, Radstoek, Somersetshire. Sedgwiek Museum, Cambridge.	140.
1*b*.	Ditto; proximal portion of costa and subeosta, showing the tubereular anterior edge, and the baekward slipping of the eosta over the subcosta. × 4.	140.
1*c*.	Ditto; distal portion of the eosta and subeosta, showing the spinous anterior border of the former, the eross-branehes uniting the two veins, and a median line of tubercular ornament on the subcosta. × 4.	140.
1*d*.	Ditto; proximal portion of the inner margin, showing the development of stout submarginal spines. × 4.	140.
1*e*.	Ditto; more distal portion of the inner margin, showing the submarginal spines. × 4.	140.
2.	*Tillyardia multiplicata*, gen. et sp. nov.; impression of the under surface of right wing. × 1½. Upper Coal Measures; Barony Pit, Auchinleck, Ayrshire. Mus. Geol. Surv. Scot., no. T. 4098 *b*.	145.
3.	*Archimylacris pringlei*, Bolton; basal two-thirds of fore-wing. × 4. Upper Coal Measures (Keele Group); Slang Lane, Wellington, Shropshire. Mus. Pract. Geol., no. 30725.	146.

Bolton, Insects of Coal Measures. PLATE X.

2.

3/2



1a.

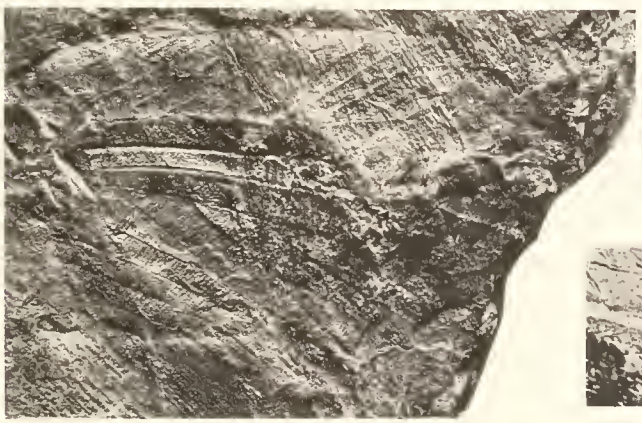
2/1

1b.

4/1

1c.

4/1



3.

4/1

1e.

4/1

1d.

4/1

1a-e. BOLTONITES. 2. TILLYARDIA.

3. ARCHIMYLACRIS.

J W. Tutcher, photo

London Stereoscopic Co imp

SMITHSONIAN INSTITUTION LIBRARIES
3 9088 00765 6978